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SPORT. VLAANDEREN

Primary prevention of sports-related injuries in and through physical education teachers:

feasibility, effectiveness and transferability to the adolescents

PRIMARY PREVENTION OF SPORTS-RELATED INJURIES IN AND THROUGH PHYSICAL EDUCATION TEACHERS: FEASIBILITY, EFFECTIVENESS AND TRANSFERABILITY TO THE ADOLESCENTS

SIEN VERCRUYSSE

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Content

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SAMENVATTING

De grote letselproblematiek bij adolescenten verhindert hen om te genieten van de gezondheidsvoordelen die bekomen kunnen worden door fysiek actief te zijn en te sporten. Bovendien brengen letsels ook vele bijkomstige negatieve gevolgen met zich mee zoals afwezigheid op school. Om alle jongeren te bereiken, zowel zij die actief zijn in een sportclub als zij die deelnemen in niet-georganiseerde sport, werd de school uitgekozen om letselpreventie via de leerkrachten lichamelijke opvoeding (LO) in de lessen LO te implementeren. Leerkrachten LO zijn bevoegd (bachelor/master diploma) en capabel (vb. didactische vaardigheden) om letselpreventieve kennis en gedrag over te brengen naar de jongeren, maar omwille van hun hoge fysieke werkbelasting (vb. heffen van zwaar materiaal) en hun uitgebreide sportverleden, zijn ook leerkrachten LO niet gespaard van sport- en werk-gerelateerde letsels. Bovendien, zijn zij meestal ook nog aan het sporten tijdens hun carrière als leerkracht en vervullen vaak ook de rol van sportcoach naast hun uren. Daarom zijn de doelen in dit proefschrift tweeledig; enerzijds wordt gefocust op letselpreventie bij leerkrachten LO om een letselvermindering bij hen te bekomen en anderzijds wordt gefocust op een verandering in het lesgeefgedrag van leerkrachten LO om jongeren te bereiken via de lessen LO en om jonge atleten in de sportclub te bereiken.

Eerst en vooral werd een epidemiologische studie opgestart bij 103 leerkrachten LO en 58 andere vakleerkrachten (Hoofdstuk 1). Gebaseerd op de definitie van een sport- of werk gerelateerd letsel hadden leerkrachten LO 0.83 letsels/ leerkracht LO/ schooljaar, wat hoger was dan de andere vakleerkrachten (0.36). De meeste letsels bij leerkrachten LO waren nieuw (51%), non-contact (76%) en acuut (62%), en de meest getroffen lichaamsdelen waren de rug (18.8%) en knieën (17.3%). De resultaten van deze eerste studie konden gebruikt worden om een bestaand multifactorieel letselpreventief programma, “No Gain With Pain”, verder aan te passen zodat het aangepast is voor onze doelgroep, de leerkrachten LO. Het “aangepaste NGWP 1.0” werd via drie cycli van implementatie, evaluatie en optimalisatie geleidelijk aan geoptimaliseerd, zodat het volledig past bij de noden en wensen van de leerkrachten LO (Hoofdstuk 2). Appreciatiescores verbeterden na de optimalisaties en zowel gepercipieerd nut van en vertrouwen hebben in het correct uitvoeren van de strategieën, als de letselpreventieve

kennis van de leerkrachten steeg overheen de tijd. In hoofdstuk 3 werd de effectiviteit van het “aangepaste NGWP 1.0” geëvalueerd via een gerandomiseerd onderzoek met controlegroep (n=55) en resulteerde in een verminderde letselincidentie in de interventie- (0.38 sport- of werk gerelateerde letsels/ leerkracht LO/ schooljaar) vergeleken met de controlegroep (0.73). Effecten werden hoofdzakelijk gevonden in de vermindering van non-contact letsels. De tijd dat aan het uitvoeren van letselpreventief gedrag besteed werd verschilde niet tussen beide groepen, hoewel een meer gebalanceerd gebruik van de strategieën gerapporteerd werd in de interventiegroep. Hoofstukken 1, 2 & 3 zorgden samen voor de optimalisatie van het bestaande multifactorieel letselpreventief programma, NGWP, zodat het kon gegeven worden aan leerkrachten LO en effectief was in het verbeteren van hun letselpreventieve competenties en letselvermindering teweeg bracht (doel 1).

Om het tweede doel van dit proefschrift te bereiken, werd een gerandomiseerd onderzoek met controlegroep uitgevoerd bij 14 leerkrachten LO en 271 leerlingen (Hoofdstuk 4). Het “aangepaste NGWP 2.0” richtte zich op de transfer van letselpreventie via de leerkracht naar de leerlingen in de lessen LO. De letselpreventieve kennis van de leerkrachten steeg na het krijgen van de interventie en ze gebruikten ook vaker preventief gedrag als ze zelf gingen sporten. Het belangrijkste in hoofdstuk 4 was de toename van het gebruik van de strategieën in de lessen. Er waren enkele onenigheden tussen rapporteringen van leerkrachten en leerlingen over het letselpreventief gedrag in de lessen, maar omdat er een andere schaal gebruikt werd om de strategieën te quoteren is het moeilijk om vergelijkingen tussen beiden te maken. Als laatste werd het “aangepaste NGWP 3.0”, met focus op de transfer naar de jonge atleet in de sportclub, aangeboden in een gerandomiseerd onderzoek met controlegroep. Letselpreventieve kennis steeg opnieuw bij de leerkrachten en een toename in het gepercipieerd nut werd gevonden voor eigen sportactiviteiten, voor de lessen LO, maar niet voor trainingen in de sportclub. Er werd wel een toename gevonden van letselpreventief gedrag in alle drie de contexten. Met deze laatste twee studies (hoofdstuk 4 & 5) werd letselpreventie in een multisport adolescente populatie bereikt via het trainen van leerkrachten LO om de transfer in hun lessen en op trainingen te maken (doel 2).

SUMMARY

The large problem of injuries is preventing youngsters from obtaining the health benefits that can be derived from physical activity and sport. Moreover, injuries entail a lot of additional negative consequences for adolescents such as school absences and educational failure. To reach all adolescents, whether being active in a sports club or participating in non-organized sports, the school context was chosen in which injury prevention can be implemented through physical education (PE) teachers in PE lessons. PE teachers are qualified (bachelor/master degree) and capable (e.g. didactical skills) of transferring the injury preventive knowledge and behaviour towards the adolescents. However, their high physical work load (e.g. carrying and lifting heavy loads) and extensive history of sports participation pose them at high risk of sports- and work-related injuries. Moreover, they are often still active in sports during their career and often engage as a sports coach in addition to their regular job. Therefore, the objectives in this dissertation are twofold; on the one hand focusing on the implementation of injury prevention strategies in lives of PE teachers to reduce their injuries and on the other hand changing PE teachers' preventive behaviour towards adolescents in physical education lessons and towards athletes in sport clubs.

First of all, an epidemiologic study in 103 PE teachers, compared to 58 non-PE teachers was designed (Chapter 1). Based on the definition of a sports- or work related injury, PE teachers sustained 0.83 injuries/ teacher/ school year, which was higher than non-PE teachers (0.36). Most injuries in PE teachers were first-time (51%), non-contact (76%) and acute (62%) and the most affected body parts were the back (18.8%) and knees (17.3%). The results of this first study could be used to further shape the content of the existing multifactorial injury prevention intervention, "No Gain With Pain" (NGWP), so that it better fitted the context of the target population of PE teachers. The "adapted NGWP 1.0" program was revised in a next study, in which three cycles of implementation, evaluation and optimization allowed to gradually improve NGWP, so that it optimally fits the needs and wishes of PE teachers (Chapter 2). Appreciation scores improved as a result of the optimizations made, and perceived utility of the strategies, confidence to apply the strategies, and teachers' knowledge about prevention strategies were found to increase over time. In chapter 3 the effectiveness of

the “adapted NGWP 1.0” was evaluated through a randomized-controlled trial in 55 PE teachers and resulted in a reduced injury incidence in the intervention group (0.38 sports- or work related injuries/ PE teacher/ school year) compared to the controls (0.73). Effects were mainly found in the reduction of non-contact injuries. The amount of time performing preventive behavior did not differ between intervention and control groups, however a more balanced use of the strategies was seen in the intervention group. Together chapters 1, 2 & 3 allowed for the optimization of the existing multifactorial injury prevention intervention, NGWP, so that it could be delivered to PE teachers and was effective in increasing teachers’ injury prevention competences and lowering their injuries (aim 1).

Then, to reach the second objective in this dissertation, a randomized-controlled trial was designed in 14 PE teachers and 271 pupils (Chapter 4). The “adapted NGWP 2.0” included modules to specifically target transfer through PE teacher to the pupils in the PE lessons. Teachers’ injury prevention knowledge increased after receiving the intervention and they also engaged more frequently in preventive behavior when playing sport themselves and showed an increase in all preventive strategies. Most important to chapter 4, an increased application of preventive strategies in teachers’ PE lessons was reported. There were some disparities in the teacher and students reports on injury prevention in PE lessons, but comparisons are difficult to make because assessments were completed with different rating scales in both groups. Finally, the “adapted NGWP 3.0”, including modules to specifically target transfer to adolescent athletes in a sports club, was delivered to an intervention group in a randomized-controlled trial in 49 PE teachers. Again, improvements in PE teachers’ knowledge were seen. Increased perceived utility of the strategies was reported in teachers’ own sporting activities, in PE lessons, but not in trainings. Most importantly, the study resulted in an increased application of the provided strategies in teachers’ own sporting activities, in their PE lessons, as well as in their trainings. With the latter two studies (chapter 4 and 5), injury prevention in a multi-sport adolescent population was reached by training PE teachers to effectively transfer the prevention strategies in their PE lessons and/or in trainings at club level (aim 2).

GENERAL INTRODUCTION

Why is injury prevention needed for young sports participants, how can this be established and what can be the role of the Physical Education teacher?

When you start to read this dissertation, one of the first questions that arises will probably be: "Why is sports injury prevention so important for adolescents?". The answer leads us to a discussion about the importance of engaging in physical activity and sports for health, and a presentation of the current physical activity and sport participation rates of Flemish adolescents.

A definition of physical activity (PA) and the position of sports is first given before discussing the many benefits of an active lifestyle. Physical activity is defined as any bodily movement produced by skeletal muscles that results in energy expenditure (Caspersen et al., 1985). Physical activity can be divided into occupational PA and leisure-time PA. Occupational PA usually refers to activities that are part of an 8-h working day, whereas the duration of leisure-time PA is quite variable. The latter form of PA includes all forms of aerobic activities, structured endurance exercise programs, resistance-training programs, and sports activities (Howley, 2000). So sports is a subcategory of physical activity, which contains movement activities with a sporty character, in a sporting leisure time context (Scheerder et al., 2015).

Leisure-time PA has been associated with health benefits, educational and psychological advantages, as well as social gains (Fraser-Thomas et al., 2005; Holt et al., 2011; Ulseth, 2004). For example, self-esteem and mental health are positively affected by PA during adolescence (Hallal et al., 2006). In the long term, being physically active as an adolescent reduces the risk of breast cancer. Also, a long-term protective effect of adolescent physical activity on bone health has been detected. Furthermore, the review of Hallal et al. (2006) made clear that adolescent PA is moderately related to PA during adulthood as well, such that activity levels track into adulthood. Studies have shown that adults who are more physically active benefit in terms of reduced risks of developing major cardiovascular and metabolic diseases, obesity, falls, cognitive impairments, osteoporosis and muscular weakness (McPhee et al., 2016).

Despite the many benefits of being physical active, statistics of the World Health Organization (WHO) show that worldwide the prevalence of obesity nearly doubled between 1980 and 2008. Moreover, estimations of the number of overweight infants and children in the WHO European Region indicate that 60% of children who are overweight before puberty will be overweight in early adulthood.

Recommendations for adolescent physical activity[1] of the WHO include: 1. At least 60 minutes of moderate to vigorous-intensity PA should be done daily, 2. PA of amounts greater than 60 minutes daily will provide additional health benefits, 3. PA should include activities that strengthen muscle and bone, at least 3 times per week (WHO, 2016). WHO states that globally 81% of adolescents (11-17 years) were insufficiently physically active in 2010.

Concerning the adolescents aged 15-17 years in Flanders, Belgium, 83.7% engaged in sports participation[2] in 2014. Within this sample 58.4% participated in club-organized sport[3]. An increase in physical activity and sports participation in Flemish adolescents was found between 2009 (81.8%; Scheerder et al., 2013) and 2014 (Scheerder et al., 2015). Clearly this development is encouraging given the important health benefits associated with sport participation in adolescence. As Scheerder et al. (2013; 2015) used a broad definition of sports participation[1], an overestimation of the sports participation in Flanders may be given. In the report of the European Injury Data Base (EU IDB) for the years 2010-2012 was found that almost 4 out of 10 Europeans aged 15 years and over participated in sport once a week. While 15-24 year olds engaged for 60% in sport at least once a week, the proportion decreased to only 28% for the 55+ category.

In the report of EU IDB for the years 2010-2012 it is mentioned that home, leisure and sports injuries account for 74% of all hospital treated injuries, and that 6.2 million people

[1] For children and young people PA includes play, games, sports, transportation, chores, recreation, physical education, or planned exercise, in the context of family, school, and community activities.
[2] Sports participation was defined as active participation during the twelve months prior to the study in movement activities with a sporty character, in a sporting leisure time context and without a highly functional character.
[3] Club participants declared to have practiced at least one sport in a club-organized context during the last 12 months, regardless of the frequency, intensity or level of this sports practice.

were being treated for a sports injury in this two year period. About one third (33%) of these sports injuries affected adolescents and young adults (15-24 years), whereas this population represents only 12% of the total EU population (European population statistics). Also in Belgium, 70% of all acute injuries in the Flemish youth (6-18 years) is due to sports activities (Cumps and Meeusen, 2006). So, sports injuries might be more likely to occur in adolescents as an unintended and unwanted consequence of increasing numbers of participants (Scheerder et al., 2013; 2015). As the EU IDB is a data source based on injuries treated in emergency departments in the EU, which include mostly severe injuries, there will be an underestimation of the total amount of sports injuries. Even so in the study of Cumps and Meeusen (2006) only registrations of emergency departments in four Belgian hospitals were taken into account.

Now, let's get back to our opening question: "Why is sports injury prevention so important for adolescents?". The large problem of injuries is preventing youngsters from obtaining the health benefits that can be derived from physical activity and sport (Hallal et al., 2006). This because youth sports injuries are one of the main reasons for drop-out in organized sports activities (Indridadottir et al., 2015; Crane & Temple, 2015) and accounts for 8% of the drop-out in recreational sporting activities (Grimmer et al., 1988). Moreover, injuries entail a lot of additional negative consequences for adolescents such as school absences (Barnes et al., 2001), educational failure (Klerman, 1988), reduced social contact with their classmates, discomfort, dysfunction and transport problems (Sörensen et al., 1998), and some long-term health effects (e.g. osteoarthritis; Maffulli et al., 2009). The latter issue, together with for example medical costs are consequences affecting the parents of the injured adolescent as well. Due to the various negative effects of the injuries, an increased demand for injury prevention has arisen in order to enlarge the population of adolescents that is able to remain physically active (WHO, 2016) and presumably to optimize the participation of all of these young people. The aim of the current dissertation, that derives from existing research (Goossens et al, 2015) on effective injury prevention in university students, was to develop and test interventions aiming at effectively preventing sports injuries in adolescents.

A more detailed overview of the general introduction

In the general introduction first more details concerning sports injury incidences, injury localization, characteristics and risk factors in adolescents are provided. In this dissertation, only reports of musculoskeletal injuries are provided. Following the epidemiology and aetiology, some major consequences of injuries for adolescents' young lives will be given.

Secondly, a main determinant for effective injury prevention will be the focus, namely the ways in which preventive strategies are delivered. This is crucial because adherence to preventive strategies has proven to be an important determinant for success, in terms of minimizing injuries in young people. With this in mind, self-determination theory (Deci and Ryan, 2000) is proposed as a way to develop autonomous motivation to adhere to the preventive strategies (Chan and Hagger, 2012).

Thirdly, we will motivate what the role of the physical education teacher can be in the prevention of sports injuries in youngsters. Injury prevention can take place at several sites where adolescents are active, for instance, in the sports club or at school. Because in Flanders, compulsory physical education counts from the year a child turns six years till the year the adolescent turns 18 years, we choose to target the school as context for injury prevention delivery. In that way, not only the youngsters active in a sports club, but also the youngsters participating in non-organized sports participation could be reached. Moreover, injury prevention is part of the final requirements of physical education in secondary school. In addition, physical education teachers are well qualified (bachelor/master degree) and capable (e.g. didactical skills) of transferring knowledge and behavior towards his/her adolescents in adequate ways (e.g. using self-determination theory). There are two additional advantages of working with physical education teachers. First, they are often active as a coach or trainer in a sports clubs, so transfer from the school context towards the sports club is possible. It is suggested by White et al. (2014) that coaches' intention to deliver safety programs in their training sessions might improve if their role models (e.g. high profile coaches) are doing so as well. When trying to reach injury prevention in adolescents, it might be more successful if their role models (e.g. PE teachers and/or coaches) are implementing preventive

strategies in their own behavior as well, and therefore we also focus on the population of physical education teachers. Secondly, physical education teachers also suffer from sports and work related injuries themselves (e.g. Pihl et al., 2002; Kovač et al., 2013). This high injury prevalence in physical education teachers can boost their awareness of the usefulness of injury prevention. Therefore, we present studies on physical education teacher's lifestyle including the combination of a physically demanding job and a wealth of sporting activities in the present and the past. Hereby, the number of injuries, injury localization and characteristics, activity while incurring an injury and some associated consequences in this population will be reported.

In the fourth place, we will take a closer look at the possible content of a primary injury prevention intervention. "Primary" injury prevention aims to prevent injuries before it ever occurs. Therefore, studies on effective injury prevention strategies will be presented and the importance of a multifactorial approach in a multisport population will be put into the spotlight.

Finally, the research objectives and outline of this dissertation will be provided. These are summarized in a conceptual model (De Clercq et al., 2011; Figure 1) that was tested as part of the current dissertation. The conceptual model gives an overview of the direct (intervention for physical education teachers) and indirect pathways (from physical education teachers to students, from physical education teachers to sport clubs) for the transfer of injury prevention concepts. The objectives in the model, and thus in this dissertation, are twofold; on the one hand focusing on the implementation of prevention strategies in lives of physical education teachers to reduce their injuries and on the other hand changing physical education teachers' preventive behavior towards adolescents and towards athletes in sport clubs to decrease the injury incidence in the latter.

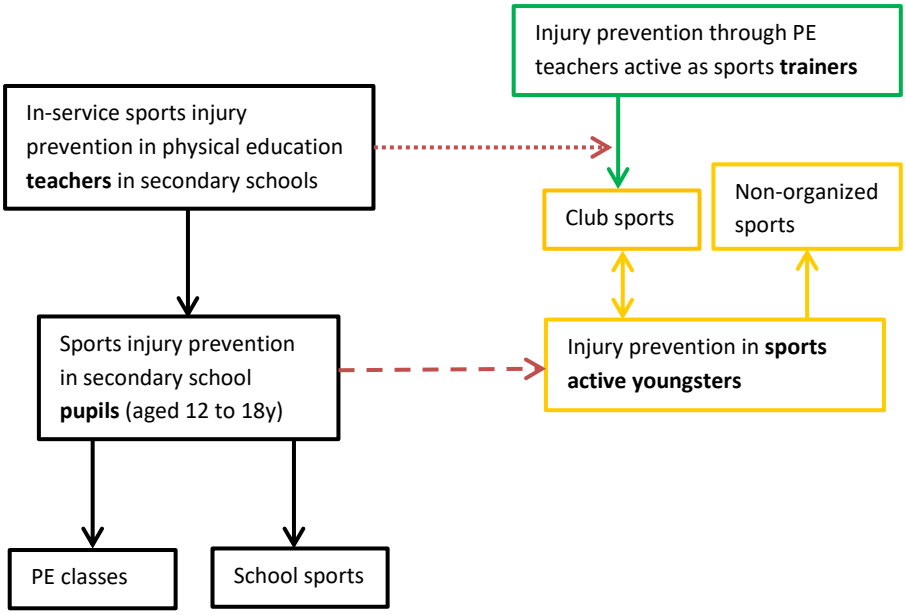

Figure 1. Conceptual model of direct and indirect pathways for the transfer of injury prevention concepts of De Clercq, Haerens and Goossens, 2011.

1. Sports Injuries, characteristics and consequences in adolescents

1.1. Sports Injury incidence of adolescents

The most common way to report the incidence of sports injuries of adolescents is expressing the number of injuries per 1000 hours of exposure to sports (e.g. training and match hours of playing basketball). Injury incidences between 1.30 and 8.14 injuries per 1000 hours of exposure were found (Beachy and Rauch, 2014; Malisoux et al., 2013; Theisen et al., 2013; Vanderlei et al., 2014).

In general, for sports-active adolescents in Brazil, 1.30 injuries per 1000 hours of exposure were found by Vanderlei et al. (2014). According to Theisen et al. (2013), the general sports injury incidence was 4.3 injuries per 1000 h among adolescents in Luxembourg. Beachy and Rauch (2014) reported 8.137 injuries per 1000 athlete-exposures (AEs[4]) among middle school athletes from 1988-2008 in Honolulu, Hawaii. Girls experienced 7.578 injuries/ 1000 AEs, whereas boys had 8.547 injuries/ 1000 AEs. For the adolescent high-level athletes in Luxembourg, 2.81 injuries/ 1000 h were reported by Malisoux et al. (2013). In the Netherlands an injury incidence of 3.8 injuries/ 1000 h among 10-14 year old athletes and 3.9 injuries/ 1000 h in 15-19 year olds was found (van Galen and Diederiks, 1990).

Furthermore, approximately one injury per four students and one injury per three instances of participation (recreational and/or sporting activity) was found among primary school students (aged 11-12 years) and third-year high school students (15-16 years) in South Australia (Grimmer et al., 2000). Emery and Tyreman (2009) found 60.85 injuries/ 100 students/ year in junior high school students (12 to 15y) in Calgary, Canada. According to EU IDB estimates each year, about one third of all sports injuries treated in the hospital, account for adolescents and young adults (15-24 years), whereas adolescents only represent 12% of the total EU population. However, as mostly young adults (15-24 years) are participating in sports (EU IDB), most injuries could be expected in this population. Overall, the rate of hospital treated injuries in young people is highest

[4] An AE was defined as 1 athlete participating in 1 practice or game.

in the domains of “home & leisure” and sports injuries. While 15-24 year olds engaged for 60% in sport at least once a week, the proportion decreased to only 28% for the 55+ category.

About 5% of all school children are seriously injured during PE lessons yearly (Hübner and Mirbach, 1992; Kemeny, 1988). In school physical education, Kelm et al. (2001) investigated accidents and the associated injuries. During 18 months, 213 accidents during physical education in school were registered in the surgical outpatient clinic in Germany, which caused 234 injuries among youngsters aged 11 to 15 years.

These studies all point towards a relatively high injury incidence among physically active adolescents compared to the total EU population.

1.2. Injury localization among adolescents

In general, the mostly affected body parts of adolescents are lower limbs (66.5%), followed by upper limbs (21.3%) and trunk (12.8%; Vanderlei et al., 2014). This was the case in both individual (lower limbs: 61.4%; upper limbs: 21.7%; trunk: 13.0%) and team sports (77.9%; 13.0%; 8.4% respectively; Theisen et al., 2013). Ankles (21.2%) and knees (15.7%) were the most frequently injured body parts, followed by the wrists (8.4%), head (7.51%) and hands (7.51%; Emery, 20009). In line with these results, Beachy and Rauch (2014) reported ankle (19.3%), knee (12.8%), thigh (11.8%), shin/calf (10.0%) and wrist/hand/finger (8.5%) as the most injured body parts in young athletes. Female athletes are mainly injured at the lower limbs (78.4%), and show some injuries at the upper limbs (10.49%) and head and back (9.28%). In male athletes, the majority of injuries are also at the lower limbs (57.81%), but also upper limbs (19.6%) and head and back (20.77%) are substantially represented (Beachy and Rauch, 2014). Also, van Galen and Diederiks (1990) stated that the ankle was the most injured body part in adolescents. The injuries occurring during physical education lessons were investigated in only one study, which suggested that injuries in PE are mainly located at the upper extremity (55%), with mostly hand and fingers being injured (41%; Kelm et al., 2001). The lower extremity (37%) was in second place, with the ankle joint being mostly injured (20%). In third place head injuries (4%) occurred.

Overall, these studies point to the direction that the largest part of the injuries among adolescents are situated at lower limbs. However, during PE lessons upper limbs are frequently injured as well, with most commonly hand and fingers. As in this dissertation is wanted to reach all adolescents, injury localizations during different sports (e.g. football and swimming) and different sport activities (e.g. game, training, PE lesson) should be taken into account.

1.3. Injury characteristics among adolescents

The most common injury types among adolescents are ligament sprains (23.9%), fractures (16.03%) and muscle strains (14.7%; Emery, 2009). According to van Galen and Diederiks (1990), contusions and sprains are the most common injuries in adolescents. During physical education lessons, most injuries were sprains (30.7%), contusions (27.7%) and fractures (16.7%; Kelm et al., 2001). In individual sports muscle and tendon injuries (35.1%), capsules and ligaments injuries (27.1%), fracture or other bone trauma (16.7%) and contusion (17.4%) are most present (Theisen et al., 2013). For team sports, injury types are muscle and tendon injuries (45.1%), capsules and ligaments injuries (22.9%), fracture or other bone trauma (16.3%) and contusion (13.0%; Theisen et al., 2013).

Furthermore, Malisoux et al. (2013) found that of all injuries recorded, 42.0% were traumatic non-contact, 34.8% traumatic contact, and 23.2% overuse injuries. Also Vanderlei et al. (2014) reported non-contact injuries as most common.

1.4. Injury risk factors of adolescents

The intrinsic (e.g. bone density) and extrinsic (e.g. parental pressure) risk factors among adolescents can be situated in the dynamic, recursive model of aetiology in sport injury of Meeuwisse et al. (2007; figure 2). The cyclic approach supports the idea that an injury is not the endpoint, but adaptations are likely to appear even in case of no injury occurrence.

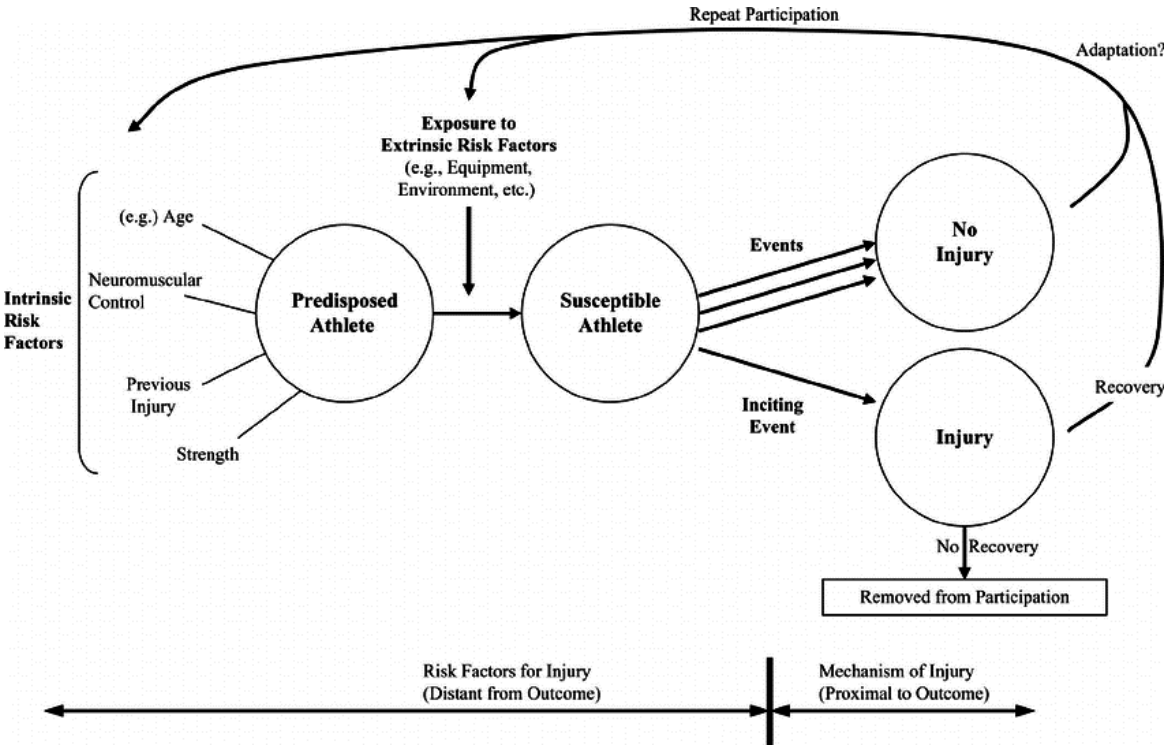

Figure 2. A dynamic, recursive model of aetiology in sport injury (Meeuwisse et al., 2007).

In general, male adolescents participating in sport are at greater injury risk than girls, but in soccer, baseball, and basketball, an increased injury risk is present among girls (Emery, 2003). In gender-matched sports, middle school girls are more likely to sustain an injury or time-loss injury than middle school boys. Middle school girls are more likely to sustain an injury in practice than during a game, while the risk of injury is similar during practices and games for middle school boys (Beachy and Rauch, 2014). Also, it seems that girls are at greater risk of sustaining a knee injury, and the knee injury is more likely to require surgery or to involve the anterior cruciate ligament. Equally, girls seem to be at greater risk than boys of sustaining an ankle injury and being reinjured. However, differences of injury risk according to sex are not always found (e.g. Vanderlei et al., 2014; Emery and Tyreman, 2009). Overall, these studies about gender differences in injuries are thus inconclusive, as conflicting results were found depending on the context (practice, game) or the type of activity.

As for the role of age, Theisen et al. (2013) found that the older the adolescent, the lower the injury risk, and the age with the highest risk of school sports injuries was designated at 13 years (Kelm et al., 2001). However, no increased injury risk by age was

reported by Emery and Tyreman (2009). Moreover, the relation between age, grade and competitive levels and injury rates seems to be sport-specific (Caine et al., 2008). So, the impact of age as injury risk factor seems arguable as different statements are made in the literature.

Thirdly, the type of sport may influence the injury risk to adolescents. Different injury risks could be found in individual and team sports (Theisen et al., 2013). Athletes from team sports (6.16 injuries/ 1000h) had a 2.14 times higher injury risk than those from individual sports (2.88 injuries/ 1000h; Theisen et al., 2013). This also counts for young (12-19 years) high-level athletes (Malisoux et al., 2013). Sport-specific findings could be reported for age, grade and competitive levels and injury rates (Caine et al., 2008).

In general, some sports pose a greater injury risk than others for adolescents, such as football (16.030/1000 AEs; Beachy and Rauch, 2014) (41-61% of athletes injured annually; Adirim and Cheng, 2003), basketball (14%), soccer (12%), hockey (8.6%), snowboarding/skiing (7.1%) and cycling (6.2%; Emery and Tyreman, 2009). Another study by Aaron and LaPorte (1997) found that wrestling and gymnastics count for 40-46% of all injuries in adolescents, basketball for 31-37%, and volleyball, baseball, soccer, cross country, softball and track for 7-18%. In contrast, diving, tennis, water polo, swimming, and golf reported the lowest injury rates (Beachy and Rauch, 2014).

Injury risks differ according to gender, whereby for girls' track and field (12.167/1000 AEs in Beachy and Rauch, 2014), netball, basketball, soccer and gymnastics are the sports where most injuries occur (Emery, 2003; Grimmer et al., 2010). In turn, adolescent boys are mostly injured in wrestling (9.954/1000 AEs in Beachy and Rauch, 2014), martial sports, hockey, Australian Rules Football, hockey, basketball, and football (Emery, 2003; Grimmer et al., 2010).

Lastly, soccer (21.2%), basketball (19.6%), and gymnastics (16.5%) are the top three of mostly performed sports while incurring an injury during physical education lessons (Kelm et al., 2001).

In short, injury risks for adolescents differ among the types of sport, but also gender plays a role in the type of sport practiced with the associated injury risks.

Moreover, the following additionally intrinsic[5] injury risk factors were found; decreased bone density in amenorrhoeic female athletes, deconditioning, rapid growth, poor dynamic balance, poor preparation (Caine et al., 2008; Kerssemakers et al., 2009), weighing more and being taller (Vanderlei et al., 2014). Also, a higher number of competitions per 100 days led to an increasing injury risk in team sports, while the opposite was true for individual sports (Theisen et al., 2013). However, in a large prospective follow-up at the National Collegiate Athletic Association, Hootman et al. (2007) concluded that the difference between training and competition-related injury rate was much higher in sports with traditional player contact (e.g. judo) than in those with no player contact (e.g. swimming). A higher amount of exposure to risk (average number of sporting hours per week over one year) and a higher number of sports in which the students were coached were identified as injury risk factors (Emery and Tyreman, 2009; Vanderlei et al., 2014). A previous injury has been postulated to increase the risk for (re)injury and this was already confirmed in various studies (Caine et al., 2008; Robey et al., 1971; Mueller and Blyth, 1974; Theisen et al., 2013).

So, various intrinsic risk factors (decreased bone density, deconditioning, rapid growth, poor dynamic balance, poor preparation, higher number of competitions per 100 days, amount of exposure to risk, number of sports in which the students were coached, and a previous injury) were found in adolescents and need special attention.

Extrinsic[6] injury risk factors among adolescents are reported for inappropriate training (Kerssemakers et al., 2009), parental pressure (Brenner, 2007) and life stress (Caine et al., 2008). Also, sporting equipment should ideally be optimized and attention should be given to the environment, especially the surface on which the activity is to be performed (Outerbridge et al., 1995; Dalton, 1992).

Besides the distinction between intrinsic and extrinsic injury risk factors, a distinction is also made between non-modifiable (i.e. these factors can't be changed, such as age or body length) and modifiable (i.e. adolescents can do something about it, such as

[5]Intrinsic risk factors can cause an injury through something that you have control over
[6]Extrinsic risk factors can cause harm or damage to yourself although it is out of your control

flexibility or muscle strength) risk factors. In an intervention focus should mainly be put on the latter.

1.5. Consequences of being injured as an adolescent

First of all, the presence or absence of injuries affects whether youngsters can experience the health benefits associated with physical activity and sport participation (Hallal et al., 2006). This is because youth sport injuries are one of the main reasons for dropout from organized sports activities (Indridadottir et al., 2015; Crane & Temple, 2015) and accounts for 8% of the drop-out in recreational sporting activities (Grimmer et al., 1988). Furthermore, school absences after injuries were reported by Barnes et al. (2001) and by Sörensen et al. (1998), which may lead to educational failure, particularly when adolescents miss more than 11% of school days (Klerman, 1988). Moreover, if adolescents are not able to participate in the physical education lessons and in leisure time PA, they may also experience less social contact with their peers. Transport problems when travelling to school are detected in 23.7% of the injured adolescents (Sörensen et al., 1998). Fifteen percent of the parents reported an absence from work due to the injury of their child. Average absence was 2.2 days per injury (range 0 - 44 days), which represents a total loss of 431 working days for the parents. Financial loss of missed working days or missed days from an after-school job and medical costs for the parents may appear. Injuries might also influence adolescents' attitudes towards sports and physical activity and lead to inactivity (Kerssemakers et al., 2009). On the long-term was shown that men, being active in sports during their life, had an increased risk of knee osteoarthrosis (Sandmark and Vingard, 1999). Also Garrick (2003) showed that injuries during adolescence may result in incomplete recovery and residual symptoms which can cause joint degeneration in the long term, limiting the ability of experiencing pain-free movements and engaging in fitness-enhancing activities during adult life. However, in the review of Maffulli et al. (2009) was concluded that more prospective cohort studies are necessary to have a good insight in the long-term health outcomes of youth sports injuries.

High injury incidences were reported among adolescents with the lower limbs being the mostly affected zones of the body. As injuries often lead to severe consequences, injury

prevention is needed for adolescents. Given that many of the injury risk factors are well-known, it is timely to start to develop injury prevention programs.

2. Adherence to an intervention

Before focusing on effective injury prevention strategies, we discuss first of all a main determinant for effective injury prevention. Professional development research (O-Sullivan and Deglau, 2006) strongly suggests a need to focus not only on content (i.e. which prevention strategies are proven to be effective), but also on the delivery approaches (e.g. interactive, practical) of a primary prevention intervention. Offering effective injury prevention strategies does not guarantee that the participants will implement them in their lives. In contrast, participants' lack of continued adherence to the proposed prevention strategies has been noted as a crucial problem in previous injury prevention programs (Myklebust et al., 2003; Verhagen et al., 2011). It has been postulated that injury prevention requires behavioral change strategies (Verhagen et al., 2010). One empirically validated theory that can help to optimize the adherence to preventive behavior is the self-determination theory (SDT; Deci & Ryan, 2000; Vansteenkiste & Ryan, 2013).

SDT conceptualizes motivation on a continuum from less to more self-determined motivation (Figure 3). Specifically, a distinction is made between a lack of motivation (amotivation), controlled motivation, and autonomous motivation (Deci & Ryan, 2000). Adolescents with amotivation lack a sense of goal-directedness and intentionality, and do not see any reason to act in a particular way (e.g. they do not understand why they would engage in injury prevention strategies). Controlled motivation can take two different forms; external and introjected regulation. External regulation is present when one performs some behavior because one feels pressured from the outside (e.g. if the adolescents do the injury prevention exercises because the physical education teacher will punish them otherwise), whereas in introjected regulation one performs the behavior out of internally pressuring reasons (e.g. anxiety of getting injured). Thirdly, with autonomous motivation one has more volitional reasons to engage in the preventive strategies. As such, identified regulation occurs if adolescents engage in an activity because they understand and endorse the value of an activity for their own (e.g.

adolescents find it important and valuable to protect themselves against injuries by engaging in the prevention strategies) and integrated regulation is present if someone understand the life values and global lifestyle (e.g. in order to maintain a healthy lifestyle adolescents engage in injury prevention), whereas intrinsic motivation is present when adolescents engage in an activity out of enjoyment and experience challenge in the activity itself (e.g. they enjoy doing preventive exercises and challenge themselves by trying a higher level).

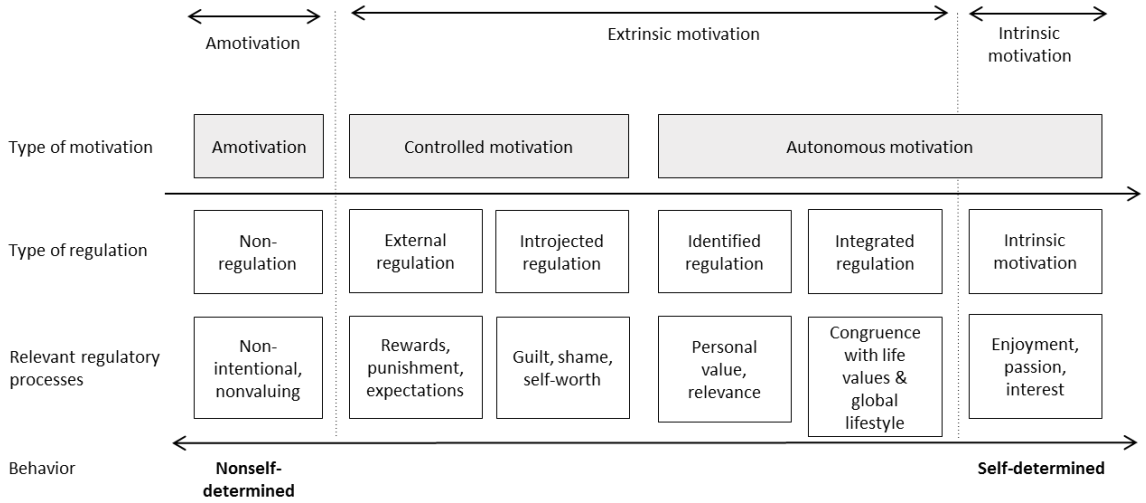

Figure 3. The motivational continuum according to Self-Determination Theory (based on Ryan & Deci, 2000).

SDT suggests that individuals will be more autonomously (i.e. more optimally) motivated to change their behavior when their three basic psychological needs are fulfilled: autonomy, competence and relatedness (Deci & Ryan, 2000). They are then more likely to either enjoy or understand the value of the proposed behavioral change (Chan and Hagger, 2012). Supporting the need for autonomy (i.e. a sense of volition and psychological freedom when engaging in an activity; Deci and Ryan, 2000) in the context of sports injury prevention can be nurtured by providing, for example, choices in exercises. Secondly, the need of relatedness (i.e. the experience of closeness, trust or friendship in relationships with others; Baumeister and Leary, 1995) can be provided by creating a positive atmosphere among the participants and allowing interaction during the intervention. Thirdly, the need for competence (i.e. feelings of success and effectiveness; White, 1959) can be supported by providing attainable exercises.

3. The role of the physical education teacher in the prevention of sports injuries in youngsters

It is known already that injury prevention is needed in adolescents and self-determination theory provides a well-evidenced framework to optimize the delivery approach of the intervention. Now, the most suitable actor to provide the intervention towards the adolescents in an appropriate setting should be chosen.

According to Emery et al. (2006), only limited responsibility for child sport injury prevention should be placed on the child itself (e.g. performing balance exercises during a sports activity). In contrast, parents (e.g. providing appropriate sports equipment), but mainly the sports coach (e.g. including core stability exercises in sport trainings) carry important responsibility. Also sports organizations and governments are highly responsible for child sport injury prevention. Thus the organized extra-curricular sports context (e.g. introducing prevention strategies during sports trainings) seems ideal, but only adolescents active in organized sports can be reached this way. In contrast, during physical education lessons all adolescents (whether being active in a sports club or participating in non-organized sports) can be reached, as physical education lessons are compulsory in primary and secondary schools in Flanders. Here, the physical education teacher could have the responsibility to introduce the prevention strategies in the lives of the adolescents. This implementation would contribute to reach the final objectives, in which injury prevention is a component, of physical education in secondary school. Moreover, physical education teachers are also the driving forces in school sports activities and are often active as trainer in a sports club as well. Collard et al. (2010) and Emery et al. (2007) tried to reduce injuries in primary school children respectively through physical education lessons, and in high school basketball players through school sports. The 5-minute preventive exercise program and the sport-specific balance training program had some promising results, which show that injury prevention in adolescents through the school context is possible. Adding that physical education teachers are qualified (bachelor/master degree) and capable (e.g. didactical skills) of transferring the injury preventive knowledge and behavior towards the adolescents, they seem to be the appropriate actors.

However, before introducing an injury prevention intervention through physical education teachers, it is important to understand their experiences with injuries given their active lifestyle.

3.1. Physically active lifestyle and injuries in physical education teachers

The many benefits of having a physically active lifestyle and participating in sports not only count for adolescents, but also for adults. The WHO recommends that adults engage in 150 minutes of moderate-intensity PA throughout the week or at least 75 minutes of vigorous-intensity PA (WHO, 2016). Physical education teachers normally meet the recommendations and have better health than a reference population of other teachers (Pihl et al., 2002; Sandmark, 2000), but their lifestyle is associated with a considerable physical load. First of all, physical education teachers engage in a physically demanding job, including standing and walking, carrying and lifting heavy loads, demonstrating sports skills, aiding, and assisting adolescents (Sandmark et al., 1999; Andre et al., 1991). The physical work load on lower limbs and back for physical education teachers is considerable in comparison with other occupational groups (Sandmark et al., 1999). Secondly, physical education teachers commonly have an extensive history of sports participation (during education and in leisure time; Sandmark, 2000) and are often still active in sports (in competition or recreational) during their work career (Pihl et al., 2002). Thirdly, physical education teachers often engage as a sports coach in addition to their regular job (Kovač et al., 2011), which increases the risk of having an injury (Lemoyne et al., 2007; Bizet et al., 2010).

Work-related injuries to the lower limbs have been found to be related to kneeling/squatting, climbing stairs or ladders, heavy lifting, walking/standing and slips and trips hazards (Okunribido and Wynn, 2010), whereas work-related musculoskeletal injuries to the lower back were related to awkward lifting and prolonged periods of standing (Sterud and Tynes, 2013). Due to the latter relations and the accumulation of many physically demanding activities, high incidences of injuries can be expected for physical education teachers.

The physically demanding life of a physical education teacher could be a source of a high injury rate, which had already been investigated to a limited extent by Kovač et al. (2013), Lemoyne et al. (2007), Pihl et al. (2002), Sandmark (2000), White (1993) and Andre et al. (1991). Injury prevalence of 0.51 to 0.65 injuries/ physical education teacher/ year were found (Lemoyne et al., 2007; Pihl et al., 2002).

3.2. Injury localization and characteristics in physical education teachers

In table 1. an overview is provided of the existing studies concerning injury prevalence in physical education teachers, with indication of the (reference) population, injury definition, instrumentation, and injury localization.

	Kovač et al., 2013	Pihl et al., 2002	Andre et al., 1991	Lemoyne et al., 2007	Sandmark et al., 2000	
Population	Primary and secondary school teachers (results of the latter are provided below)	Male physical education teachers	Physical education teachers	Primary, secondary and college physical education teachers	Male physical education teachers	Female physical education teachers
References	/	Other teachers	/	Class-room teachers	Swedish reference population	
Design	Cross-sectional study	A case-control study	Cross-sectional study	Cross-sectional study	A case-control study	
Injury definition	Chronic health problems were defined as overuse injuries and/or pain in the specific joints (e.g. cervical spine pain, lower back pain) that were frequently repeated and persisted for more than a year of teaching	No clear definition was provided	No clear definition was provided	Chronic lesions were defined as injuries that persisted for more than a year of teaching, whereas recent lesions occurred during the last 12 months	Musculoskeletal pain, disorder or dysfunction of different parts of the body now or in the past	
Instrumentation	Self-administered questionnaire	Ad hoc questionnaire about the previous 12 months	Self-administered questionnaire	Self-administered questionnaire	Self-administered postal questionnaire	
	Main injured body parts (prevalence %)	Main injured body parts (in % of total)			Prevalence ratios of physical education teachers compared to a reference population	
Injury localization	Low back pain (39.9%) Knee disorder (21.4%) Shoulder disorder (21.3%) Ankle disorder (19.6%) Cervical spine disorder (18.6%) Elbow disorder (8.5%) Hip disorder (7.0%) Wrist disorder (5.7%)	Shoulder (18.6%) Knee (14.0%) Neck (9.3%) Lower back (4.7%) Hip/thigh (2.3%)	Lower limbs (55%): Knee (12.6%), Thigh (8.8%) Upper limbs (25.6%): Fingers (10.4%) Head and back (19.2%): Lumbar spine (8.7%)	Neck – upper and lower back (41.7%) Knee (21.0%) Shoulder (21.0%) Ankle/foot (19.1%)	Significantly higher lower back (1.1) and knee disorders (2.1) Not significantly different: neck (1.1), shoulder (1.3), elbow (1.0), hip (1.3) and upper back disorders (0.9)	Significantly higher elbow (1.6), knee (2.2) and lower back (1.2) disorders Not significantly different: neck (0.8), shoulder (0.8), hip (1.3) and upper back (1.0) disorders

Table 1. Overview of the epidemiologic studies in physical education teachers

As is seen in table 1, either trunk and head (Kovač et al., 2013; Lemoyne et al., 2007), upper and lower limbs (Pihl et al., 2002) or only the lower limbs (Andre et al. 1991) were reported as most injured body regions.

Moreover, specific investigation in osteoarthrosis in physical education teachers compared with a Swedish referent population, showed higher prevalence in knee (men 2.8 and women 3.2) and hip (men 0.9 and women 2.7) except for hip OA in males (Sandmark, 2000). However, in female physical education teachers a lower prevalence of osteoarthrosis in the knee joint, a similar prevalence of osteoarthrosis in the hips and greater prevalence of degenerative joint disease in the lumbar spine was found compared to the general population (White et al., 1993).

Lastly, the top three of injury types reported among physical education teachers were sprains, vertebral pain and fractures (White et al., 1993).

3.3. Activity while incurring an injury in physical education teachers

According to Lemoyne et al. (2007) most injuries in secondary school physical education teachers occurred during teaching (55%), sports and leisure (24%), collision (10%), demonstration (5%), overuse (3%) and carrying objects (2%). However, according to Andre et al. (1991), being active in a sports club was the most practiced activity during which an injury occurred, followed by teaching at school, sporting themselves, and giving training in a sports club. For injuries occurring during teaching physical education, lack of warming up, helping students, demonstration, displacement of materials and stress or tiredness were the most reported reasons.

The few studies conducted concerning injuries in physical education teachers provide a small insight in this topic, although several limitations apply. First of all, retrospective designs with recall periods between one year and the entire career were used, and it is well known that recall periods for musculoskeletal injuries of over 12 months have a serious risk for recall bias (Gabbe et al., 2003). Secondly, the study populations were restricted to older (Pihl et al., 2002), male (Pihl et al., 2002) or female physical education teachers (White et al., 1993), or the reference population of non-physical education

teachers was small (Lemoyne et al., 2007). Thirdly, there is a lack of a clear injury definition in most studies.

3.4. Consequences of being injured as physical education teacher

Injuries in physical education teachers do not only reduce the numerous health benefits of sports participation (Haskell et al., 2007), but might damage teachers' personal activities (e.g. being unable to engage in leisure time activities) and cause a direct effect on adolescents due to professional obstructions (e.g. being absent from work, providing fewer demonstrations, not teaching certain sports disciplines any longer).

On the short term, nearly 25% of the injuries lead to movement limitations and over 60% lead to adapted teaching (e.g. fewer demonstrations). Over 40% lead to medical follow-up and serious injury results in a median sick leave of 14 days (Kovač et al., 2013; Lemoyne et al., 2007). A study among Swedish teachers showed that sick leave is higher in physical education teachers compared to a reference population and, in the longer term, more female physical education teachers than the reference population have to change work or work tasks because of knee injuries (Sandmark, 2000). Moreover, because of alterations in physical education teachers' musculoskeletal and osteotendinous systems, career reorientations or anticipated retirements in their forties occur (Skiöld, 1999; Bizet et al., 2010; Sandmark, 2000). Further, lower back injuries in physical education teachers (Kovač et al., 2013; Pihl et al., 2002) are often cited (Deyo & Weinstein, 2001) as a major cause of disability (e.g. prolonged absence from work; Lemoyne et al., 2007) and inability to work (e.g. the inability to assist adolescents). The disability or inability to work takes away the chance for physical education teachers to function as a sportive reference model towards the adolescents. Also, financial (Cumps and Verhagen, 2008), mental health (e.g. becoming demotivated) and social issues (e.g. less social contact with students and athletes) may occur, as well as physical discomfort (e.g. transport difficulties, difficulties in the housekeeping).

4. Injury prevention intervention

As injury prevention is needed in both adolescents and physical education teachers, developing an injury prevention intervention, fitting for the general multisport population, is warranted. Many injury prevention strategies have proved their effectiveness in reducing injuries in specific sports populations. Based on an extensive literature review of effective preventive strategies, the multifactorial intervention "No Gain with Pain" was earlier developed in Flanders (Goossens et al., 2015). No Gain With Pain was originally developed to prevent injuries in physical education teacher education (PETE) students. The multifactorial intervention consisted of an awareness program and the implementation of prevention strategies in the sports lessons, and ran during one academic year. In injury prevention usually a distinction is made between effective intrinsic (e.g. Amako et al., 2003; Cumps et al., 2007; Emery & Meeuwisse, 2010) and extrinsic strategies (e.g. Lambson et al., 1996; McKay et al., 2001; Milgrom et al., 2001). Intrinsic prevention measures involve factors that relate to the physical attributes of the athletes themselves. These strategies focus on conditioning the athlete by making him or her stronger and able to withstand the demands of the sport, resulting in a decreased risk of sport-related injury (Schiff et al., 2010). Based on an extensive literature review (Goossens, 2015), the following injury prevention strategies were selected in No Gain With Pain: warm up, pre-activity dynamic stretching, post-activity static stretching, core stability, dynamic lower extremity stabilization, functional lower extremity strengthening, and technical training for correct landing and cutting movement execution (Goossens et al., 2015). PETE students received an awareness program, which consisted of an information brochure, a one and a half-hour theoretical course given before the start of the academic year, handouts, posters on the campus and a supporting website. The implementation of the preventive strategies in the sports lessons was conducted through the sports lecturers. They took part in a three-hour theoretical-practical workshop, wherein they were informed about the injury incidence in PETE students and the rationale for each preventive strategy. They were also asked to encourage the students to use appropriate footwear for their lessons and to respect students' decisions not to take part in a sports lesson due to physical discomfort. Implementable examples of exercises per strategy were provided and no specific

guidelines on repetition numbers were given, but gradual increases were advised. In No Gain With Pain attention was paid to approach to delivery based on the central principles of SDT. Also examples were given to the sports lecturers about how to rely on the main ideas of SDT (e.g. providing freedom of choice; challenging, but attainable goals, working in pairs) in their way of delivering injury prevention exercises for the students. An overview of the No Gain With Pain program is given in figure 4.

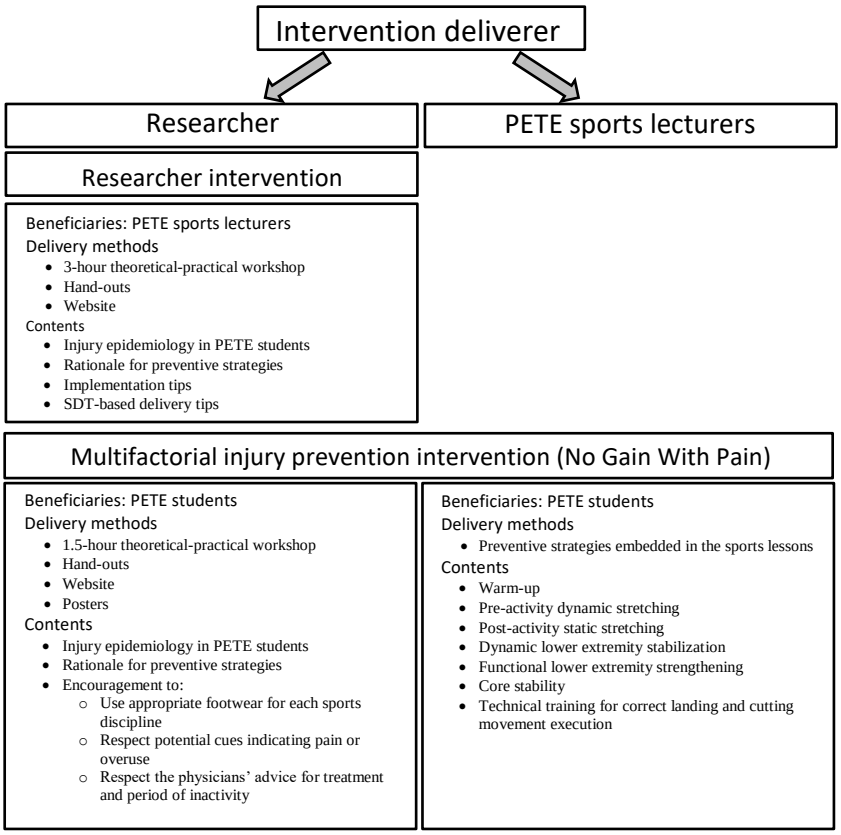

Figure 4. Schematic overview of No Gain With Pain, in Goossens et al. (2015).

No Gain With Pain was tested in a sample of first and second year bachelor students (INT: 154; CON: 189 students) in a historical controlled trial design with weekly prospective injury registrations. Overall, a trend towards a significant effect of the intervention on lower injury incidence in the intervention was found (INT: 2.18 injuries/1000 h; CON: 2.73 injuries/1000 h; $p = 0.061$). First-time, acute, extra-curricular injuries and injuries during practice sessions were lower in the intervention group in comparison to the controls. So, the multifactorial primary injury prevention intervention was tested and shown to be effective in a multisport population of students (Goossens et al., 2015).

No Gain With Pain was based on an extensive literature review of injury preventive strategies. As such it serves as a sound evidence-base for intervention studies with multi-sport populations. Both physical education teachers and all adolescents, the target populations in the current dissertation, (whether being active in a sports club or participating in non-organized sports) need a general multisport injury prevention intervention.

Although many different definitions and sometimes numerous studies can be found in literature, in the following section each preventive strategy will be defined briefly and some effective studies will be given

4.1. Warm up and cooling down

Warm up can be defined as increasing muscle/tendon suppleness, stimulating blood flow to the periphery, increasing body temperature, and enhancing free, coordinated movement (Smith, 1994).

In contrast with a warm up, a cooling down tends to gradually decrease body temperature, heart rate, and tries to bring the body gradually back to initial conditions. Light exercises (e.g. running at a very low speed) and static stretch are most common during the cooling down.

Greek professional aerobic instructors were asked to perform a private warm up before starting a class, related to the type of program they were about to teach and private cooling down after the class, over two years. A different injury rate was reported in relation to warm up duration (15 min had a lower injury rate than 10 min and 10 min had a low injury rate than 5 min). Similar effects were found for injury rate and cool down duration (Malliou et al., 2007). Moreover, Goossens et al. (2013) found that regular engagements in a cooling-down results in a lower risk of obtaining an ankle injury in physical education student teachers.

4.2. Stretching

There are three main types of stretching, namely dynamic, static, and proprioceptive neuromuscular facilitation (PNF). Dynamic stretching uses bounces or jerky type motions

to load and stretch a muscle group. Static stretching is defined as a slow, deliberate, sustained lengthening of the muscle, and each position should be held for approximately 20 seconds to facilitate connective tissue plastic elongation. The proprioceptive PNF technique incorporates three steps: a static stretch, followed by an isometric contraction and relaxation, and finally, an additional static stretch (Amako et al., 2003). Due to the more difficult performance of the PNF technique, it may be less recommended.

Conflicting data have been reported concerning the need of stretching and the effect on injuries in sports. However, Witvrouw et al. (2004) seems to have found a clarification for it. Namely, when a sport demands stretch-shortening cycles (SSCs) of high intensity (e.g. soccer, volleyball, basketball), stretching may be important for injury prevention. But, when the type of sports activity contains low-intensity, or limited SSCs (e.g. jogging, cycling and swimming) stretching may not be advantageous. This is because for optimal performance in the latter activities, the tendons do not need to function as good energy-absorbing structures. Since the maximal energy-absorbing capacity of these unstretched (stiff) tendons is less likely to be exceeded during these sporting activities, the risk of tendon or muscle damage will be relatively low (Witvrouw et al., 2004). Evidence for this line of thought can be given. High intensity sports(-related) activities, such as football (warm-up and stretching routine after halftime; Bixler and Jones, 1992) and military trainings (static stretching; Amako et al., 2003), showed a reduction in muscle-related injuries due to stretching. In contrast, the review of Yeung and Yeung assessed the effects of stretching in the low-intensity sport jogging, where only one study had a significant effect of stretching on the incidence of injuries (hamstring stretching; Hartig and Henderson, 1999).

4.3. Balance training

Balance training may be synonymous to coordination training, improving stable postures or learning to quickly recover balance. Hereby, exercises with (e.g. balance board, semi-globe) or without materials (e.g. standing on one leg, closing your eyes) can be performed.

High school basketball and soccer players seemed to have a lower risk of sustaining ankle sprains if they performed a balance training program (McGuine and Keene, 2006). Balance exercises needed to be performed in both pre- and competitive season and included single- or double leg stances, with and without the use of a balance board and with integration of functional sports activities such as dribbling. In line with this, an in-season basketball-specific balance program, applying balance semi-globes, was delivered to basketball players and seemed also effective in lowering the risk of lateral (recurrent) ankle sprains (Cumps et al., 2007). Mostly ankle injuries seem to benefit from balance training (e.g. high school football players: McHugh et al., 2007; female handball players: Wedderkop et al., 1999; volleyball players: Verhagen et al., 2004), and also acute-onset injuries are less likely to happen when delivering a home-based balance training program using a wobble board in adolescent basketball players (Emery et al., 2007). Moreover, a home-based balance training with wobble board improved static and dynamic balance after six weeks of daily practice and decreased the injury risk in adolescents over six months (Emery et al., 2005). Non-contact hamstring injuries and tendinopathy of the patella and Achilles tendon could be reduced in female elite soccer players by a soccer-specific balance training (Kraemer and Knobloch, 2009).

4.4. Functional strength training

Functional strength training has strong focus on individual characteristics and therefore should be performed according to an individual's needs. This may be performing strength training in a specific joint (e.g. strengthening of the rotator-cuff in order to avoid shoulder luxation when weak muscles are detected) or in a specific muscle (e.g. strengthening the hamstrings when there is an imbalance detected in the hamstrings according to quadriceps in the same leg).

Although functional strength training is very different for each individual, some sport-specific injuries can suggest certain functional strength training. An example is the study of Petersen et al. (2011), where soccer players performed eccentric strengthening of the hamstrings, as acute hamstring injuries are a common injury in this population. Positive effects were found in overall, new and recurrent acute hamstring injuries. The earlier study of Arnason et al. (2008), showed similar effects of eccentric strength training in

soccer players. Also, in intercollegiate[7] swimmers functional strength training for the shoulder was implemented and reduced shoulder pain (Swanik et al., 2002).

4.5. Core stability training

Core stability is the ability to control the position and motion of the trunk over the pelvis to allow optimum production, transfer and control of force and motion to the terminal segment in integrated athletic activities (Kibler et al., 2006).

According to the review of McGill (2010), the so called 'Big 3', which includes the curl-up, side bridge and quadruped bird-dog, is integrated in many injury prevention programs. An example is a study in female gymnasts, where the intervention group performed the big three during 10 weeks of biweekly trainings. Improvements of four trunk endurance tests were seen in the intervention group and overall, no new low back pains were reported in the following season (Durall et al., 2009). In a sample of soldiers it was found that core stability training resulted in less time absent due to low back injuries (Childs et al., 2010).

4.6. Correct performance

Correct performance refers to performing exercises in a way that can protect you from being injured (e.g. a correct landing technique after performing a jump, correctly performing cutting movements).

Technical training for correct landing skills and cutting movement execution in a sample of elite junior Australian football players in a preseason training intervention reduced the chance of sustaining an injury during the following season (Scase et al. 2006).

4.7. Appropriate footwear

Appropriate footwear is an extrinsic prevention strategy quite easily applicable for adolescents (and their parents). This means footwear must be chosen according to the

[7] Intercollegiate refers to participating in a competition between colleges

kind of sports activity, individual and surface in order to prevent injuries (Benazzo et al., 1999).

Four different types of football shoes were tested in a population of high school football players. One seemed to produce much more torsional resistance than the others and resulted in a higher amount of anterior cruciate ligament injuries (Lambson et al., 1996). Among basketball players, wearing shoes with air cells in the heel seemed to increase the chance of having an ankle injury 4.3 times compared to wearing shoes without air cells (McKay et al., 2001). These studies show that evidence exists of the association between the incurrence of injuries and the type of sports shoes.

4.8. Multifactorial intervention

The previously mentioned prevention strategies showed their effects on certain sport specific populations or types of injuries. However, an enormous list of risk factors was presented (see 1.4.) and Meeuwisse et al. (2007) showed in his dynamic, recursive model that a lot of different factors determine the aetiology of sports injuries. Interventions aiming at several possible injury-inducing factors and thus trying to counteract a wider range of injury mechanisms, can lower the occurrence of musculoskeletal injuries in sport-specific populations (Parkkari et al., 2001). These are the so-called “multifactorial interventions”. So, in order to prevent overall injuries in adolescents, each of the identified effective intrinsic strategies is preferably not only implemented separately, but also in a balanced combination. In previous studies effective multifactorial injury prevention interventions have been developed (e.g. Aerts et al., 2013; Arnason et al., 2008; Emery et al., 2005; Olsen et al., 2005). These studies emphasized the importance of implementing different preventive strategies instead of focusing on only one to obtain injury reduction. The knowledge derived from these studies formed the basis to develop No Gain With Pain (Goossens, 2015), which is one of the few studies offering a multifactorial injury prevention program in a multisport population (Goossens et al., 2015). As such the latter intervention formed a good basis for the studies that are outlined in the present dissertation.

5. Research objectives and outline of the thesis

The conceptual model of De Clercq, Haerens and Goossens (2011) outlining different pathways towards injury prevention in PE teachers and adolescents, served as a basis for the current dissertation. Different paths of the model were tested. In figure 4 is pointed out which parts belong to which particular goals and chapters.

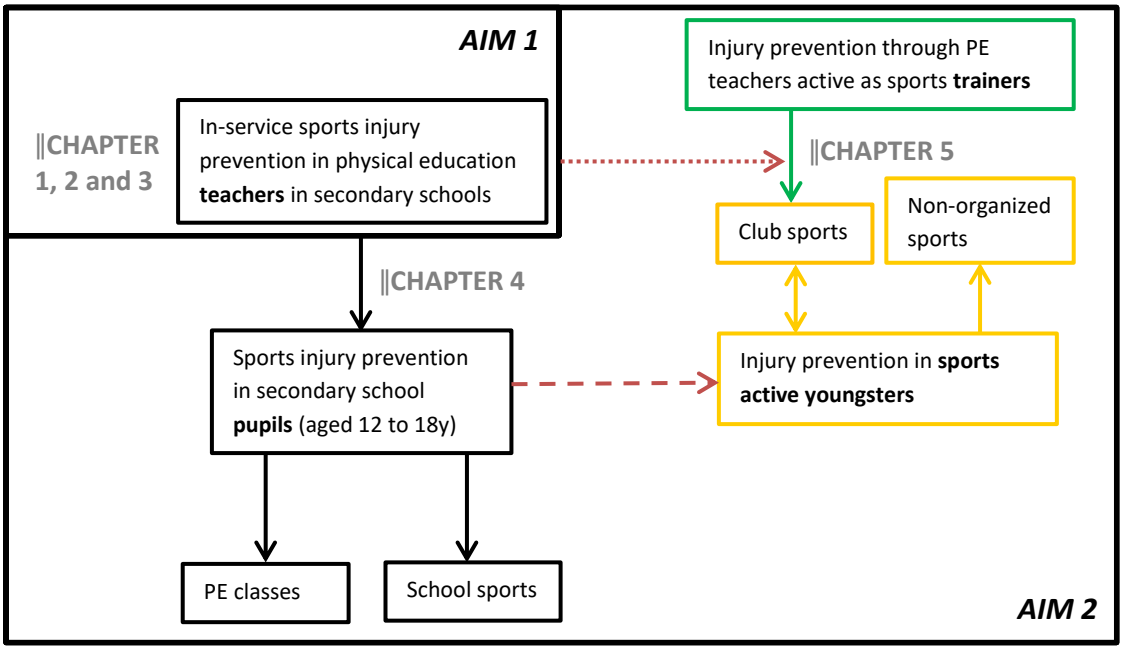

Figure 4. An overview of the different target populations in this dissertation with indication of the five chapters and two aims, based on the conceptual model of De Clercq et al. (2011).

The objectives in the model, and thus in this dissertation, are twofold; on the one hand focusing on the implementation of prevention strategies in lives of physical education teachers to reduce their injuries (Chapter 1, 2, 3) and on the other hand changing physical education teachers' preventive behavior towards their students (in physical education) (Chapter 4) and towards sport participants (in the sport club) (Chapter 5) to reduce the injury incidence in the latter.

Aim 1: Optimization of a primary multifactorial injury prevention intervention so that it is well-appreciated and effectively increases physical education teachers' injury prevention competences and lower their injuries.

The first step in the optimization of No Gain With Pain was tracking the epidemiology in the first specific target population, namely the physical education teachers. We did so by addressing a number of gaps in the current literature. As only a few epidemiologic studies in physical education teachers exist in the literature (see 3.1.), only three studies compare injuries in PE teachers with a reference population (Sandmark, 2000; Pihl et al., 2002; Lemoyne et al., 2007), and no prospective registrations were done yet, a prospective epidemiologic study that addressed these limitations (i.e. Including a reference group) was set up.

Based on the argumentation of Twellaar et al. (1996), namely that the teacher's choice to report a musculoskeletal problem as an injury best corresponds with daily reality, an injury definition was determined prior to starting this study:

"An injury was defined as any musculoskeletal problem (all types of damage to muscle, tendon, bone, joint or ligament) that occurred during one school year regardless of the location and the severity of the problem."

The first research goal in chapter one was then to gain more insight in the epidemiology of musculoskeletal injuries among physical education compared to non- physical education teachers in Flanders, Belgium by means of a systematic prospective study. Further research objectives were to map the characteristics of musculoskeletal injuries among physical education teachers in terms of localization, type, damaged tissue and circumstances of the inciting event and to determine differences between physical education and non- physical education teachers regarding demographics, habitual physical activity, sports injury history, teacher career and time of exposure (**CHAPTER 1**).

After having gained insight into the epidemiology of injuries among PE teachers (Chapter 1), an intervention for PE teachers could be developed. Therefore, chapter two aimed at systematically developing and optimizing the content and delivery approach of an injury prevention intervention for physical education teachers, based on teachers' qualitative (e.g. focus group interviews) and quantitative (appreciation questionnaire) evaluation of the intervention. As for the development of the content and delivery approach of this intervention, we could rely on the No Gain With Pain program (figure 4), supplemented with findings from the literature on the epidemiology of injuries among adolescents and

PE teachers, and the findings of our study among physical education teachers (results of chapter 1).

Once the intervention was optimized and fulfilled the wishes and needs of the physical education teachers ("adapted No Gain With Pain 1.0"), an effect study could take place during one school year (September – June). The goal of this study was to assess the effects of this multifactorial intervention on the occurrence of sports- or work-related injuries and preventive behaviors in physical education teachers, through a randomized-controlled trial design (**CHAPTER 3**).

Aim 2: Pursuit of injury prevention implementation in sports active adolescents through physical education teachers transferring the prevention strategies in their lessons and/or in trainings at club level.

Once the injury prevention intervention was optimized and tested with physical education teachers, the focus could be shifted towards the adolescents. So, the aim was to investigate whether it is possible to train physical education teachers to implement preventive strategies in their PE lessons, as to reduce injuries in adolescents with an "adapted No Gain With Pain 2.0". In order to stimulate transfer, a first goal in chapter four is to test whether we could improve injury preventive knowledge in physical education teachers. Secondly, it was investigated whether the adapted intervention resulted in increased preventive behavior of physical education teachers in their PE lessons (**CHAPTER 4**).

In the final chapter of this dissertation, we investigated whether it is possible to reinforce the transfer of preventive strategies through physical education teachers towards sports club trainings. In the last chapter in this dissertation it was thus investigated if an "adapted No Gain With Pain 3.0" was effective in not only changing physical education teachers' knowledge and preventive behaviors (see Chapter 3), but also their preventive behavior towards students in PE (see Chapter 4) and towards adolescents in trainings context (**CHAPTER 5**).

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CHAPTER 1 || *MUSCULOSKELETAL INJURIES IN PHYSICAL EDUCATION VERSUS NON- PHYSICAL EDUCATION TEACHERS: A PROSPECTIVE STUDY*

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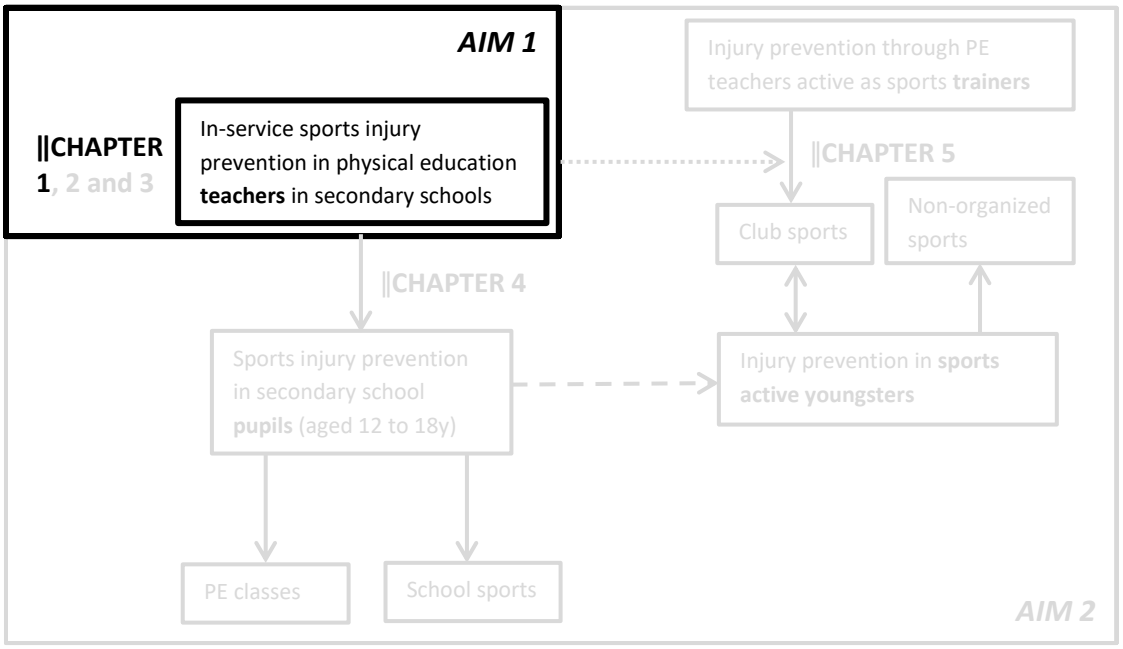

AIM 1
‖CHAPTER 1, 2 and 3
In-service sports injury prevention in physical education **teachers** in secondary schools
‖CHAPTER 4
Sports injury prevention in secondary school **pupils** (aged 12 to 18y)
PE classes
School sports
Injury prevention through PE teachers active as sports **trainers**
‖CHAPTER 5
Club sports
Non-organized sports
Injury prevention in **sports active youngsters**
AIM 2

ABSTRACT

Physical education (PE) teachers have a physically demanding job, putting them at a considerable risk for musculoskeletal injuries. To structurally develop tailored injury prevention programmes for PE teachers, a clear understanding of the extent, characteristics and underlying factors of their musculoskeletal injuries compared to referents is necessary. Therefore, the current study prospectively followed 103 PE teachers and 58 non-PE teachers, who registered musculoskeletal injuries and time of exposure to sports participation during one school year. Pearson $\chi 2$-tests and independent samples t-tests determined significant differences between PE and non-PE teachers regarding demographics and variables possibly related to injury occurrence. PE teachers had 1.23 and non-PE teachers 0.78 injuries/teacher/school year. This difference was significantly different after adjustment for hours spent weekly on intra-curricular teaching during the career and for injury history during the preceding six months ($P = 0.009$; OR = 0.511; 95% CI = 0.308–0.846). PE teachers' most affected body parts were the knee and the back. PE teachers had a more extensive injury history ($P < 0.001$), a higher work- ($P < 0.001$) and sport index ($P < 0.001$), practiced more sports ($P < 0.002$) and taught more extra-curricular sports ($P = 0.001$). Future injury prevention programmes should take account for the great injury history and heavy physical load in PE teachers.

Introduction

Physical education (PE) teachers have to deal with a considerable physical load caused by prolonged standing and walking, demonstrating sports skills, assisting pupils, lifting and carrying heavy loads. Sandmark, Wiktorin, Hogstedt, Klenell- Hatschek, and Vingård (1999) revealed that the physical work load on the lower limbs and back in PE teachers is considerable compared to other occupational groups. In general, workrelated musculoskeletal injuries to the lower limbs have been found to be related to kneeling/squatting, climbing stairs or ladders, heavy lifting, walking/standing and slips and trips hazards (Okunribido & Wynn, 2010), whereas work-related musculoskeletal injuries to the lower back were related to lifting/pulling/pushing heavy objects and prolonged periods of walking or standing (Macfarlane et al., 1997). Due to the latter

relations, high incidences of musculoskeletal injuries can be expected in PE teachers. In addition to these work-related risk factors, most PE teachers have a considerable sports participation history (Sandmark, 2000) and current sports participation (Pihl, Matsin, & Jurimae, 2002), which place them at a higher risk for sports injuries.

Musculoskeletal injuries occur rather frequently in PE teachers. Epidemiological studies observed an occurrence of musculoskeletal injuries ranging from 0.51 to 0.65 injuries/PE teacher/year (Lemoyne, Laurencelle, Lirette, & Trudeau, 2007; Pihl et al., 2002). Regarding musculoskeletal injuries, a higher prevalence was found in PE teachers compared to a randomly selected reference population (Sandmark, 2000) and compared to non-PE teachers (Lemoyne et al., 2007). Regarding degenerative joint disease to the lumbar spine, a higher prevalence was found in female PE teachers compared to closely aged-matched woman in the general population (White, Wright, & Hudson, 1993). However, some studies found an equal or lower prevalence of musculoskeletal injuries in male PE teachers compared to non-PE teachers (Pihl et al., 2002) and of osteoarthrosis in female PE teachers compared to closely aged-matched woman in the general population (Bird, Hudson, Eastmond, & Wright, 1980; Eastmond, Hudson, & Wright, 1979; White et al., 1993). The current literature is not consentient with regard to the location of the injuries. Lower and upper limbs (Pihl et al., 2002), trunk and head (Lemoyne et al., 2007) and lower limbs alone (Andre, Cloes, & Deroanne, 1991; Kovac, Leskosek, Hadzic, & Jurak, 2013) were reported to be the most injured regions in PE teachers. Most injuries originated during the PE lessons (Kovac et al., 2013; Lemoyne et al., 2007) or during leisure time sports participation (Andre et al., 1991). In PE lessons, the main causes for injury were demonstrations, overuse, collisions and carrying objects (Lemoyne et al., 2007). Although the latter studies provide valuable information for the understanding of injury epidemiology in PE teachers, several limitations apply. All studies had retrospective designs with recall periods between one year and the entire career. Recall periods for musculoskeletal injuries of over 12 months have a serious risk for recall bias (Gabbe, Finch, Bennell, & Wajswelner, 2003). Moreover, the injury definition was not clearly mentioned, the study population was restricted to older PE teachers (Pihl et al., 2002) or the reference group of non-PE teachers was a very small sample (Lemoyne et al., 2007). As Kovac et al. (2013) stated, current PE teacher

literature lacks prospective and systematic recording and reporting of injuries, in order to provide clear and indisputable answers.

Many consequences result from musculoskeletal injuries in PE teachers. On the short term, nearly 25% of the injuries leads to movement limitations and over 60% leads to adapted teaching (e.g. fewer demonstrations). Over 40% leads to medical follow-up and serious injury results in a median sick leave of 14 days (Kovac et al., 2013; Lemoyne et al., 2007). Sick leave is higher in PE teachers compared to referents and, in the longer term, more female PE teachers than referents have to change work or work tasks because of knee injuries (Sandmark, 2000).

The extent of the problem supports the necessity of injury prevention in PE teachers. Moreover, with the essential role of PE teachers in accomplishing public health goals in mind (National Association for Sports and Physical Education [NASPE], 2004), the consequences from a public health perspective of musculoskeletal injuries to PE teachers could be considerable. The “sequence of prevention” model suggested that the epidemiology and aetiology of injuries in a specific population should first be determined, before the development of a population-specific injury prevention programme (Van Mechelen, Hlobil, & Kemper, 1992). Therefore, in preparation of the development of an evidence-based programme for the prevention of musculoskeletal injuries in PE teachers, this study aimed to gain more insight in the epidemiology of musculoskeletal injuries in PE and non-PE teachers in Flanders, Belgium, by means of a systematic prospective study. In order to improve interpretation of the results, epidemiology of musculoskeletal injuries in non-PE teachers was measured simultaneously. We hypothesised that the clinical incidence of musculoskeletal injuries would be higher in PE teachers compared to a reference population of non-PE teachers. Further research objectives were to map the characteristics of musculoskeletal injuries in PE teachers in terms of localisation, type, damaged tissue and circumstances of the inciting event and to determine differences between PE and non-PE teachers regarding demographics, habitual physical activity, sports injury history, teacher career and time of exposure.

Methods

Participants

Before the start of school year 2012–2013, 211 secondary school PE teachers and 125 secondary school non-PE teachers in Flanders (Belgium) signed in to take part in the study. Of these, 132 PE teachers (63%) and 77 non-PE teachers (62%) completed the baseline questionnaire. Analysing the frequencies of the number of prospective registrations per teacher, we observed that 75% of the non-PE teachers completed at least 30 registrations and 75% of the PE teachers completed at least 35 registrations, out of a maximum of 43 registrations. We chose to exclude data of teachers who did not complete a minimum of 30 registrations and also did not fill out a retrospective questionnaire. Final analyses were done with data of 103 PE teachers (46 males, 57 females; 45.4 ± 9.5 years; range: 36) and 58 non-PE teachers (18 males, 40 females; 41.5 ± 10.7 years; range: 37). In Belgium, teachers with a bachelor diploma can teach in grades one (13–14 years old) and two (15–16 years old) and have a maximum of 24 lessons (50 min) of intra-curricular teaching weekly, and teachers with a master diploma can teach in grades one, two and three (17–18 years old) and have a maximum of 20 lessons of intra-curricular teaching weekly. For additional information, consult the website of the Flanders Ministry of Education: http://www.ond.vlaanderen.be/.

Injury definition

An injury was defined as any musculoskeletal problem (all types of damage to muscle, tendon, bone, joint or ligament) that occurred during one school year regardless of the location and the severity of the problem. The argumentation of Twellaar, Verstappen, and Huson (1996) was followed, namely that the teacher's choice to report a musculoskeletal problem as an injury best corresponds with daily reality.

Procedure

Secondary school PE teachers of all educational networks in the East-Flanders province (Belgium) were invited by e-mail one month before the start of the school year to take part in the study (n = 281). Information about the study and a hyperlink for signing in

was also communicated by the pedagogical counsellor of each educational network through a newsletter. All secondary school non-PE teachers of schools in Ghent (Flanders) were visited by the researcher at the school (including schools from each educational network) during a teacher reunion in the last week before the start of the school year and were invited to take part in the study. At the start of the school year, those teachers who agreed to take part in the study received an invitation by email to sign an informed consent form and to complete an online baseline questionnaire. During the entire school year (43 weeks), all teachers were followed prospectively for injury occurrence and time of exposure (TOE) to sports participation. Each Monday morning, they received an automatically generated email with a hyperlink to the online registration form. At the end of the school year, all teachers were invited by email to fill out a retrospective questionnaire concerning missing registrations of injuries and/or TOE. The ethical committee of the Ghent University Hospital approved the protocol.

Measurement instruments

There were three types of measures. Teachers first completed a baseline questionnaire, after which the weekly registration started and at the end of the registration period teachers also completed a retrospective questionnaire. First, the baseline questionnaire included demographic questions concerning gender, date of birth and diploma. In addition, variables possibly related to injury occurrence were measured: if the teachers were also coach in a sports club (yes or no), intra-curricular teaching experience (in years) and time spent on intra-curricular teaching during the career (hours/week), sports injury history and habitual physical activity. Habitual physical activity was measured with the Baecke questionnaire (Baecke, Burema, & Frijters, 1982) and according to the guidelines, questions were clustered into a work index, sport index and leisure time index. With regard to sports injury history, the questionnaire asked for the occurrence of musculoskeletal injuries during the preceding six months, prevalence of osteoarthritis at the moment of registration and ruptures or injuries leading to surgery or intensive rehabilitation in the past. To test the reliability of the questionnaire, a separate sample of 10 PE teachers answered the baseline questionnaire twice with a time interval of one week. All dichotomous (Average Kappa coefficient = 1 ± 0; range = 0; $P < 0.01$) and ordinal or continuous variables (Average single measures intraclass correlation (two-way

mixed model; type: Consistency) = 0.88 ± 0.11; Range = 0.36) were reliable according to the Fleiss reliability scale (Fleiss, 1986).

Second, the weekly registration included TOE to sports participation (recreational, training and competition). Additionally, respondents indicated if an injury had occurred during the past week. In case an injury had occurred, they answered questions concerning injury localisation, injury type, damaged tissue, circumstances of the inciting event (questions derived from the Victorian Injury Surveillance system – Watson & Ozanne-Smith, 2000) and injury severity. Contact injuries were defined as injuries caused by contact with another athlete or sports equipment other than the playing surface. An acute injury occurred at a sudden moment in time and an overuse injury gradually developed. First-time injuries had never occurred to the participant before and recurrent injuries had occurred to the participant at least once in the past. A copy of the weekly registration questionnaire can be found under supplementary material.

Third, the retrospective questionnaire included an overview of all the weeks when the teacher had completed the online registration. The teachers were asked if, in the weeks that no registration was completed, any injury had occurred and if TOE was approximately the same as in the registered weeks. If necessary, for each injury that was not registered yet, an injury registration was completed and TOE for the missing weeks was indicated.

Data analysis and statistical analysis

Clinical injury incidence was expressed as total number of injuries/teacher/school year and 95% confidence intervals (CI) were calculated using a Poisson regression model. Significance of differences was tested with the Wald test. A P-value <0.05 was considered as statistically significant. Model quality was improved by adjusting the model with variables selected by Bayesian Information Criterion (BIC) forward selection. Only those demographic variables and variables possibly related to injury occurrence that differed significantly between PE and non-PE teachers were eligible for selection. First, each of the variables was added to the model separately and each model quality was evaluated. Then, the best model was selected. Subsequently, all remaining variables

were added to the new model separately and each model quality was evaluated. Variables were thus added one by one to the model as long as the model quality improved. A negative binomial model and a zero-inflated negative binomial model were run to test for overdispersion. We used “R” (version 3.2.1) using the function “zeroinfl”, package “pcsl” and function “lrtest” from the “lmtest” package was used to perform the likelihood ratio test (LRT).

Regarding demographic variables, Pearson χ2-tests determined if there were differences between PE and non-PE teachers regarding gender and diploma while independent samples t-tests determined if there were differences with regard to age. Regarding variables possibly related to injury occurrence, Pearson χ2-tests determined if there were differences between PE and non-PE teachers regarding occurrence of injury during the preceding six months, prevalence of osteoarthritis at the moment of registration, occurrence of ruptures or injuries leading to surgery or intensive rehabilitation in the past and being coach in a sports club. Independent samples t-tests determined if there were differences regarding work-, sport- and leisure time index, intra-curricular teaching experience, hours spent weekly on intra-curricular teaching during the career and TOE to extra-curricular sports participation in relation to being a PE or non-PE teacher. Regarding injury characteristics, Pearson χ2-tests determined if there were differences between PE and non-PE teachers in the proportion of acute (vs. overuse), first-time (vs. recurrent) and contact (vs. non-contact) injuries. Moreover, Pearson χ2- tests determined if there were differences between PE and non-PE teachers and between both genders in the proportion of injuries occurring to the various body locations. Regarding injury severity, Pearson χ2-tests determined if there were differences between PE and non-PE teachers in medical follow- up, consultation of a physician and physical therapy treatment. All statistical tests, except for the testing for overdispersion, were done using SPSS 21.

Results

The PE teachers were significantly older than the non-PE teachers (t = 2.352; P = 0.020) and significantly more PE teachers than non-PE teachers had a master diploma ($\chi 2$ = 10.173; P = 0.006). For the variables possibly related to injury occurrence, there were no significant differences between PE and non-PE teachers regarding intra-curricular teaching experience (t = 1.274; P = 0.205), current prevalence of osteoarthritis ($\chi 2$ = 3.133; P = 0.077), ruptures or injuries leading to surgery or intensive rehabilitation in the past ($\chi 2$ = 2.687; P = 0.261) and leisure time index (t = −1.820; P = 0.071). Compared to non-PE teachers, more PE teachers were also coach in a sports club ($\chi 2$ = 11.007; P = 0.001), PE teachers had more injuries during the preceding six months ($\chi 2$ = 13.655; P < 0.001), spent less hours weekly on intra-curricular teaching during their career ($\chi 2$ = 5.089; P < 0.001), had a higher TOE to extra-curricular sports participation ($\chi 2$ = −3.137; P= 0.002), had a higher work index ($\chi 2$ = −15.745; P < 0.001) and a higher sport index ($\chi 2$ = −4.589; P < 0.001) (Table 1).

During one school year, 70 out of 103 PE teachers suffered from one or more injuries with a total of 127 injuries (1.23 injuries/teacher/school year; 95% confidence interval (CI): 1.04–1.47; Males: 1.17 injuries/teacher/school year; 95% CI: 0.90–1.53; Females: 1.28 injuries/teacher/school year; 95% CI: 1.02–1.61), while 29 out of 58 non-PE teachers suffered from one or more injuries with a total of 45 injuries (0.78 injuries/teacher/school year; 95% CI = 0.58–1.04; Males: 0.78 injuries/teacher/school year; 95% CI: 0.46–1.31; Females: 0.78 injuries/teacher/school year; 95% CI: 0.55– 1.10). A significantly higher clinical injury incidence was found in PE teachers compared to non-PE teachers after adjustment for hours spent weekly on intra-curricular teaching during the career and for injury history during the preceding six months (P = 0.009; OR = 0.511; 95% CI = 0.308–0.846) (Table 2). Statistical testing revealed no overdispersion of the Poisson regression model (P = 0.7815 (Poisson vs. negative binomial); P = 0.1273 (negative binomial vs. zero-inflated negative binomial).

Table 1. Descriptives and bivariate analysis of demographics and variables possibly related to injury occurrence in PE and non-PE teachers

	PE teachers (n=103)	Non-PE teachers (n=58)		
	%	%	χ^2	*P*-value
Males	44.7	31.0	2.876	0.090
Coach in a sports club	29.1	6.9	11.007	0.001*
Master diploma	67.0	46.6	10.173	0.006*
Injury history during preceding six months	55.0	24.6	13.655	<0.001*
Current prevalence of osteoarthritis	21.4	10.3	3.133	0.070
Ruptures or injuries leading to surgery or intensive rehabilitation in the past	65.0	53.4	2.687	0.261
	Average +/- s	**Average +/- s**	***t*-value**	***P*-value**
Age	45.4 ± 9.5	41.5 ± 10.7	2.352	0.020*
Work index	3.61 ± 0.32	2.74 ± 0.36	-15.745	<0.001*
Sport index	3.49 ± 0.68	2.98 ± 0.64	-4.589	<0.001*
Leisure time index	3.39 ± 0.59	3.20 ± 0.69	-1.820	0.071
Years of intra-curricular teaching experience	16.9 ± 11.7	14.4 ± 10.0	-1.274	0.205
Average hours spent weekly on intra-curricular teaching during the career	16.7 ± 6.8	23.1 ± 7.1	5.089	<0.001*
TOE to extra-curricular sports participation	180.4 ± 159.3	106.6 ± 109.0	-3.137	0.002*

* Significantly different on α = 0.05 level; TOE, time of exposure; s, standard deviation.

Table 2. Differences in clinical injury incidence between PE and non-PE teachers

	PE teachers (n=103)		Non-PE teachers (n=58)				
Model	**Injuries/ teacher/ year**	**95% CI**	**Injuries/ teacher/ year**	**95% CI**	**OR**	**95% CI**	***P*-value**
Unadjusted model	1.23	1.04-1.47	0.78	0.58-1.04	0.629	0.448-0.884	0.008*
Model 1 *Adjusted for hours spent weekly on intra-curricular teaching during the career*	1.22	1.00-1.49	0.51	0.33-0.79	0.419	0.257-0.684	<0.001*
Model 2 *Model 1 + adjusted for injury history during preceding 6 months*	1.11	0.90-1.38	0.57	0.37-0.88	0.511	0.308-0.846	0.009*

* Significantly different on α = 0.05 level; OR, odds ratio; CI, confidence interval.

Results regarding injury characteristics can be found in Figure 1. In both PE and non-PE teachers, most injuries were acute, first-time and non-contact. No significant differences were found between PE and non-PE teachers. The distribution of injured body parts in PE teachers and non-PE teachers and in females as well as in males can be found in Figures 2 and 3. In both genders of PE as well as non-PE teachers, most injuries occurred to the lower limbs and knee and back were the most commonly injured body parts. Only in males, a significantly higher proportion of all injuries occurred to the head and face in

non-PE teachers compared to PE teachers. Results concerning injury type, injured tissues and circumstances of the injury can be found in Figures 4–7. In both PE and non-PE teachers, inflammatory injuries and strains were the mostly occurring injury types and muscles were the mostly affected tissue. Most injuries occurred during extra-curricular sports participation and intra-curricular teaching in PE teachers and during extra-curricular sports participation or after gradual development in non-PE teachers. Of all injuries that occurred in circumstances other than the specified categories, in PE teachers 60% occurred during physical work in spare time and in non-PE teachers 45.5% occurred during bicycling for transport. Of all injuries, 31.7% in PE teachers and 40.0% in non-PE teachers led to ceasing a sports or teaching activity ($\chi 2 = 1.008$; $P = 0.315$). In PE teachers 83.3% and in non-PE teachers 71.1% of all injuries led to pain during sports participation or teaching ($\chi 2 = 3.109$; $P = 0.078$) and 38.9% of all injuries in PE teachers versus 51.1% of all injuries in non-PE teachers led to missing a sports or teaching activity ($\chi 2 = 2.032$; $P = 0.154$). Of all injuries in PE teachers 35.4% needed medical follow-up compared to 44.4% in non-PE teachers ($\chi 2 = 1.229$; $P = 0.268$). In PE teachers, 25.2% of the injuries led to the consultation of a physician and in non-PE teachers 37.8% ($\chi 2 = 2.581$; $P = 0.108$). In PE teachers, 11.0% of the injuries led to physical therapy treatment and in non-PE teachers 13.3% ($\chi 2 = 0.172$; $P = 0.678$).

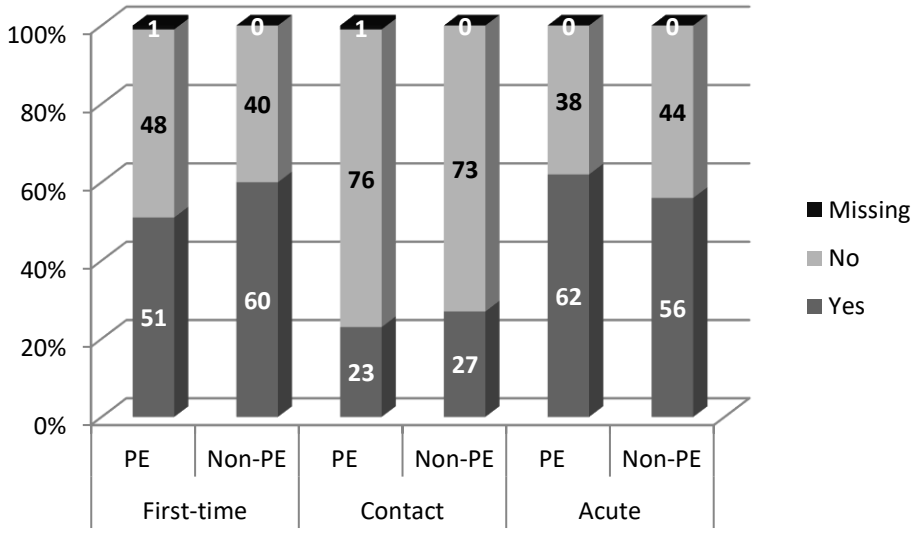


Figure 1. Distribution of first-time (vs. reinjury), contact (vs. non-contact) and acute (vs. overuse) injuries.

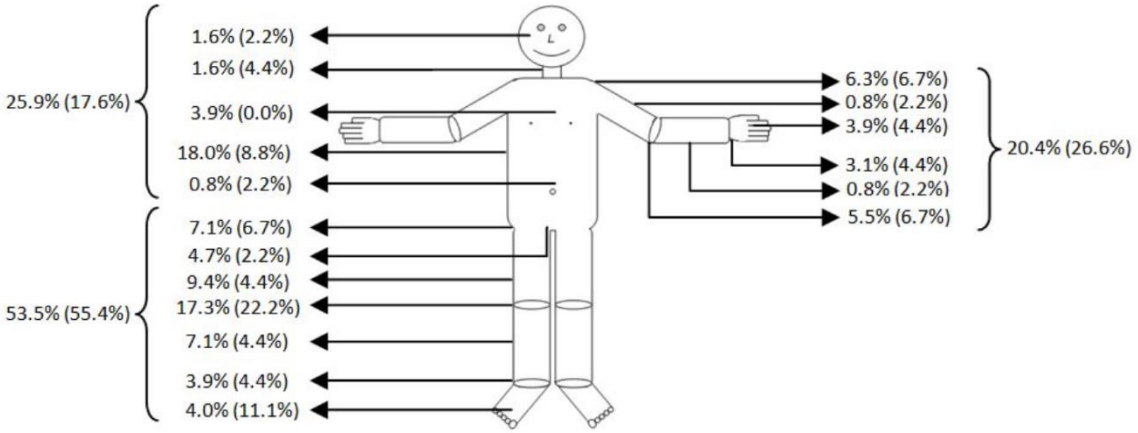
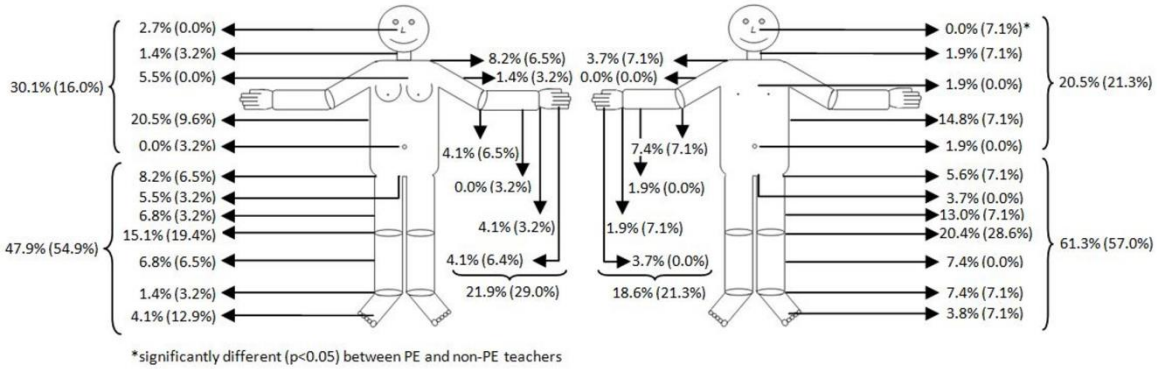


Figure 2. Distribution of injured body parts in % of total amount of injuries in PE teachers and non-PE teachers (between brackets).



*significantly different (p<0.05) between PE and non-PE teachers

Figure 3. Distribution of injured body parts in % of total amount of injuries in female and male PE teachers and non-PE teachers (between brackets).

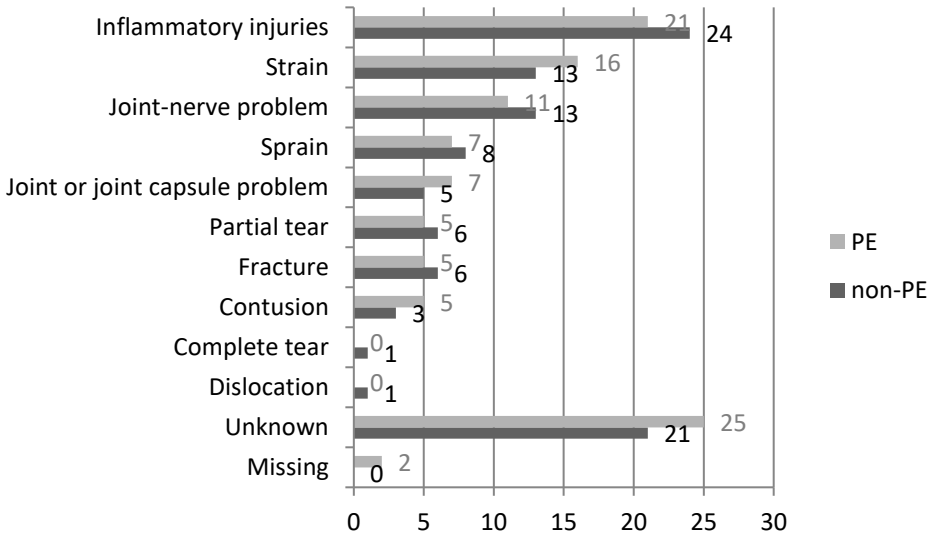


Figure 4. Distribution of injury type in % of total amount of injuries.

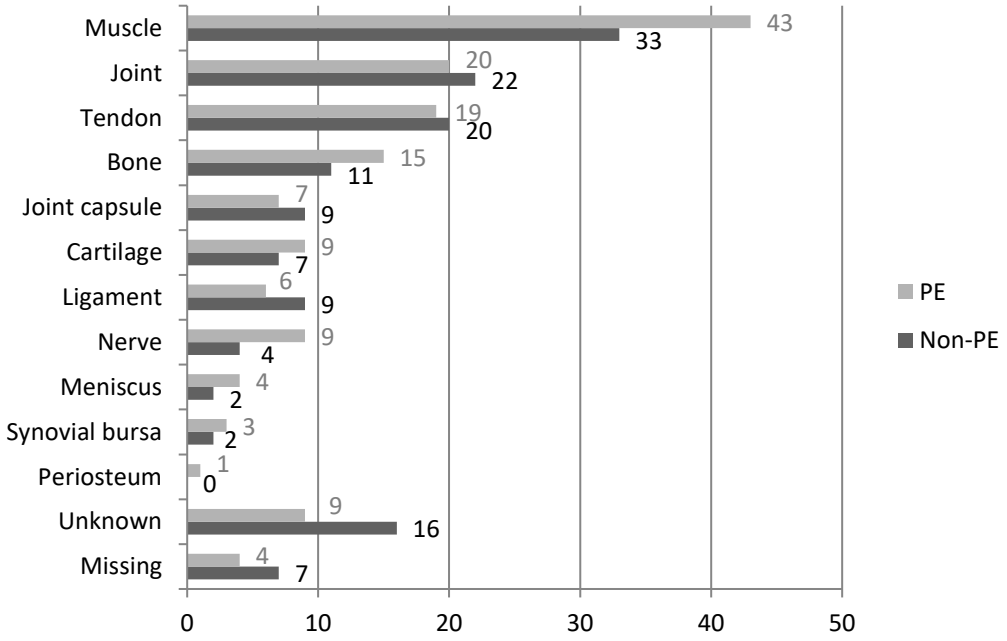


Figure 5. Distribution of injured tissues in % of total amount of injuries.

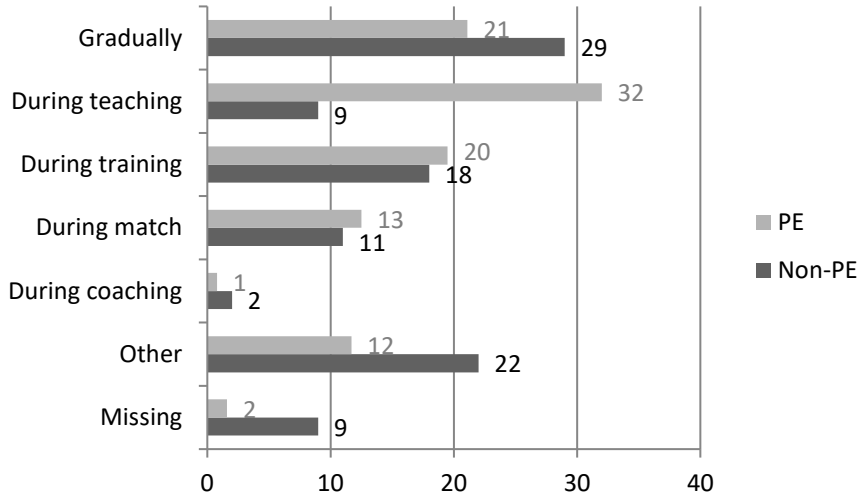


Figure 6. Circumstances of the injury in % of total amount of injuries.

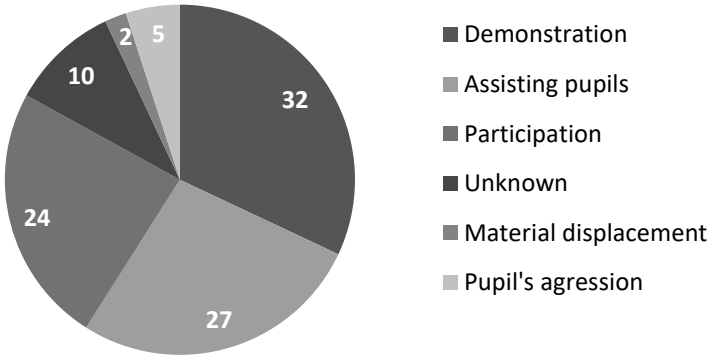


Figure 7. Circumstances of the injuries during PE teaching in % of total amount of injuries.

Discussion

This is the first prospective study on the epidemiology of musculoskeletal injuries among PE teachers. We found a clinical injury incidence of 1.23 injuries/PE teacher/school year. Other retrospective studies reported 0.51 and 0.65 injuries/PE teacher/year (Lemoyne et al., 2007; Pihl et al., 2002). The difference with the current study could be caused by recall bias in the latter studies. Another hypothesis might be the use of another injury definition. Unfortunately, both studies referred to do not explicitly mention the definition of injury applied. A secular trend of increasing overweight in adolescents during the last decade (Eidsdottir, Kristjansson, Sigfusdottir, Garber, & Allegrante, 2013)

might have also influenced the differences with previous studies. Furthermore, the PE teachers in the study by Pihl et al. (2002) were males with 58 years on average and all full-time in service. Although a mainly moderate intensity occupational physical activity level for the PE teachers was reported, one can expect less demonstrations and lifting and lower walking distances in an older when compared to a younger age group. Moreover, since at 60 years of age, only 19% of PE teachers are still working in this profession (Sandmark, 2000), the population in the study of Pihl et al. (2002) was probably a subgroup with a higher than average resistance to injuries. Also, it is unlikely that the clinical injury incidence in the study by Pihl et al. (2002) was lower due to a lack of female participants since gender has not been found to be a risk factor for injuries in PE teachers. In the study by Lemoyne et al. (2007), data were gathered through a retrospective questionnaire delivered by the heads of the PE departments. Because only one questionnaire had to be completed and cooperation was stimulated by the PE departments' heads, PE teachers with a limited injury history were possibly more motivated to take part in the study by Lemoyne et al. (2007) compared to the current study. Possibly, as a consequence of the relatively high work load involved in prospective registrations in the current study, mainly PE teachers with an extended injury history where motivated to participate in the study because they better understood the value of it.

In the current study, of all injuries in PE teachers 38% were overuse injuries compared to only 25% in the study by Lemoyne et al. (2007). Non-contact injuries made up 76% of all injuries. Earlier studies in PE teachers lack these data, although they are important in view of the future development of injury prevention programmes for PE teachers. Given the higher occurrence of non-contact injuries, the main focus of these programmes could be on intrinsic prevention strategies, which will protect the PE teacher against non-contact injuries by making the body able to withstand the acting load. Almost half of all injuries were recurrent, making a plea for extensive attention for more adequate rehabilitation in future prevention programmes. Most injuries in PE teachers were found at the lower limb, followed by the trunk and head and then the upper limb. This is in line with the results by Andre et al. (1991) and Kovac et al. (2013) who found most injuries at the lower limb. However, both Andre et al. (1991) and Kovac et al. (2013) found most

injuries at the ankle followed by the knee whereas the knee was the most injured lower limb body part in the current study and only a small proportion of injuries occurred to the ankle. The current study found more injuries in PE teachers at the back and neck than at the knee, supporting results by Lemoyne et al. (2007) who found most injuries at the back and neck. Unlike the current study, Pihl et al. (2002) found most injuries at the shoulder. Nonetheless, following the shoulder, also in their study the knee and the back and neck regions were mostly affected. Overall, regarding injury location the current study supports earlier findings from epidemiological studies in PE teachers. Concerning injury type, we found mainly inflammatory injuries and strains and only a few sprains in PE teachers, in contrast to Andre et al. (1991) and Lemoyne et al. (2007) who found mainly sprains and no inflammatory injuries. Also in the general sports-active population, sprains are among the most prevalent injury types (Cumps & Meeusen, 2006). Most probably, the different way of questioning the type of injury in various studies can explain these differences. For instance, in the current study partial or complete tears of ligaments, muscles and tendons were considered separately from sprains and strains (Figure 4). The injuries in PE teachers in the present study occurred mainly during teaching PE as well as during leisure time sports participation. In the study by Andre et al. (1991), leisure time sports activities were the main circumstance whereas both in the study by Lemoyne et al. (2007) and Kovac et al. (2013) teaching PE was the main circumstance. Here again, the current study is in accordance with these previous studies. Focusing on the injuries during PE teaching we found that most injuries occurred as a result of demonstrations, but also when assisting pupils or when participating in the lessons. The proportion of injuries in PE teachers due to demonstrations in the current study was twice the proportion reported by Lemoyne et al. (2007), who did not report the proportion of injuries caused by assisting pupils or participation in the lessons. Of all injuries in PE teachers in the current study, 35% needed medical follow-up. This result is slightly lower than the 40% reported by Lemoyne et al. (2007). The proportion of injuries leading to medical follow-up in the present study was lower in PE teachers compared to non-PE teachers. Probably, the PE teacher's background including anatomical and biomechanical knowledge resulted in a higher proportion of auto-diagnosed injuries.

Although we might have attracted a selective sample of teachers with past history of injuries, the results of the current study show a significantly higher clinical incidence of musculoskeletal injuries in PE teachers compared to non-PE teachers. These results are in line with earlier findings that the prevalence of knee osteoarthrosis, injury and surgery, elbow injury and low back pain is higher in PE teachers compared to a randomly selected reference population from the population register (Sandmark, 2000) and that the prevalence of recent injuries (Lemoyne et al., 2007) and shoulder injuries (Pihl et al., 2002) is higher in PE teachers compared to non-PE teachers. However, Pihl et al. (2002) found significantly less musculoskeletal injuries overall in PE teachers than in non-PE teachers. This difference could be largely explained by the significantly higher prevalence of neck pain in the non-PE teachers. Since blue collar work is a risk factor for neck injuries (Fredriksson et al., 1999), non-PE teachers are at higher risk for neck injuries due to their high exposure to desk activities (correction tasks, preparing lessons, etc.).

Several factors could possibly underlie the difference in clinical injury incidence between PE teachers and non-PE teachers. Firstly, PE teachers might have registered more less-severe injuries due to their background in sports, health and injuries. However, results regarding injury severity are inconclusive and several findings support the reasoning that PE teachers actually suffer more from injuries than non-PE teachers. Although PE teachers taught less hours per week (caused by a higher proportion of PE teachers with a master's degree) they still reported a higher clinical injury incidence. Analyses showed that if the PE teachers would have spent as many hours weekly on intra-curricular teaching during their past career as the non-PE teachers, the difference in clinical injury incidence between both groups would have been even greater. Probably it is not the number of hours teaching that matters, but rather the higher physical load per hour teaching that explains differences between both groups. Accordingly, in the present study over 30% of the injuries in PE teachers occurred during teaching versus less than 10% in non-PE teachers and also a significantly higher work index in PE teachers indicates a higher physical load than among non-PE teachers. In addition, PE teachers in the current study had a significantly more extensive injury history during the preceding six months than non-PE teachers and analyses demonstrated that this factor increased

the difference in clinical injury incidence between both groups. This supports earlier findings that injury history is a risk factor for injury in sports populations (Goossens, Verrelst, Cardon, & De Clercq, 2014; Kucera, Marshall, Kirkendall, Marchak, & Garrett, 2005). The reason why PE teachers have a greater clinical injury incidence during the preceding six months is unknown. Both higher physical load when teaching PE and/or a lower resistance to injuries of PE teachers could be the reason. Summarising, clinical injury incidence is higher in PE teachers compared to non-PE teachers and can be related to a higher physical load during intra-curricular teaching and/or lower resistance to injuries that can be related to a more extensive injury history. It is important though to highlight that the profession of PE teacher is not only detrimental for one's health. PE teachers participate more in sports than non-PE teachers while non-PE teachers on the other hand have a job which involves a lot of sitting. Partly due to these factors, PE teachers seem to have less serious diseases and better general health than non-PE teachers (Sandmark, 2000).

Strengths and limitations

This study is the first prospective epidemiological study in PE teachers. The study protocol consisted of a weekly questionnaire including injury registration and detailed registration of time of exposure, followed by a retrospective questionnaire in order to complete the data. In addition, the study made use of a reference group of non-PE teachers, placing the results in perspective given that a selective sample was used. Comparison of demographics and variables possibly related to injury occurrence between PE and non-PE teachers provided insight into the difference in clinical injury incidence between both groups. Nevertheless, this study has several limitations. The PE and non-PE teachers differed significantly at baseline regarding age and diploma. However, statistical analysis indicated that these factors did not significantly influence the results with regard to clinical injury incidence. In addition, in the current study no prospective registration of physical work load was done. Therefore, we were not able to detect causality with clinical injury incidence. Moreover, the retrospective questionnaire did not include a question concerning the severity of injury in terms of duration of inactivity. A combination with registration of sick leave could give further insight in the (socioeconomical) consequences of injuries in PE teachers. Furthermore, other studies

(Kovac et al., 2013; Lemoyne et al., 2007) reported a variety in injury prevalence between different teaching levels. Since the current study only studied PE teachers at secondary level, we cannot generalize this variety for the population of PE teachers in Flanders, Belgium. Additionally, since only schools in Ghent were visited, the non-PE teachers in the present study were a selective sample. Last, since self-reporting was used to obtain injury data, the possibility of missing injuries cannot be excluded.

Perspectives

The current study found a considerable clinical incidence of musculoskeletal injuries in PE teachers, which was higher than in a reference population of non-PE teachers. A more extensive injury history during the preceding six months and a higher intra-curricular physical load probably place PE teachers at a higher risk for injuries. The knee and the back were the mostly injured body parts in PE teachers, and both teaching PE and leisure time sports participation were the main circumstances of the injuries. These results provide important information for the development of injury prevention initiatives in PE teachers. Future interventions should mainly target the lower limbs and the back, with a focus on intrinsic prevention strategies because most injuries were non-contact. However, since many recurrent injuries occurred and considering the extensive injury history, also the importance of a correct diagnosis and appropriate rehabilitation should be stressed. Furthermore, since an injury history has been repeatedly determined as a risk factor for injuries in sports populations, injury prevention should be an important component of PE teacher education programmes.

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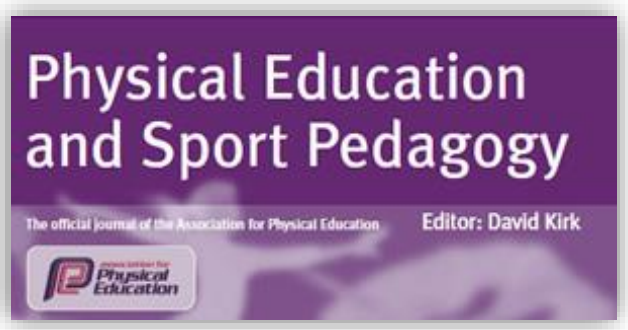
CHAPTER 2 || *DEVELOPMENT AND OPTIMIZATION OF AN INJURY PREVENTION INTERVENTION FOR PHYSICAL EDUCATION TEACHERS*



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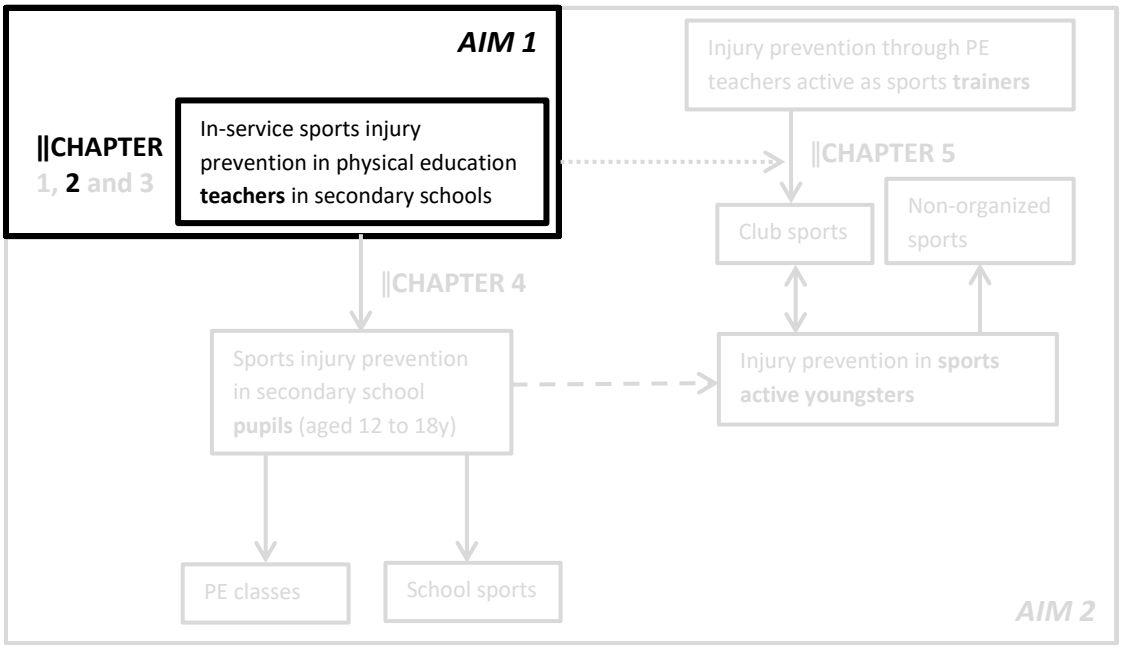
AIM 1
‖CHAPTER 1, 2 and 3
In-service sports injury prevention in physical education **teachers** in secondary schools
‖CHAPTER 4
Sports injury prevention in secondary school **pupils** (aged 12 to 18y)
PE classes
School sports
Injury prevention through PE teachers active as sports **trainers**
‖CHAPTER 5
Club sports
Non-organized sports
Injury prevention in **sports active youngsters**
AIM 2

ABSTRACT

Background: Injury prevention is highly needed in physically active populations, such as pre-service and in-service physical education teachers (PETs). As a lack of adherence to preventive strategies is problematic in injury, it seems crucial to develop and optimize interventions that correspond to the specific needs and wishes of PETs.

Aim: The purpose of the present study was fourfold. Specifically, we aimed at (1) systematically optimizing an injury prevention intervention for PETs, based on teachers' qualitative evaluation of the intervention, (2) quantitatively investigating whether the appreciation of the injury prevention intervention was higher after optimization, (3) examining whether participation in the intervention resulted in positive changes in teachers' perceived utility of, and confidence to apply the proposed preventive strategies, as well as their knowledge about these strategies, and (4) describing teachers' adherence to the proposed preventive strategies while they were engaging in the intervention.

Participants: Twenty PETs (13 men, Mage = 42.1 ± 12.17 years) from nine different secondary schools in Flanders (Belgium) voluntarily participated in this study. The intervention, based on findings from the continuing professional development (CPD) literature, and the principles of the self-determination theory, took place on two different training days (Training A and Training B) and consisted of seven intrinsic injury prevention strategies.

Data collection and analysis: Qualitative data on teachers' appreciation of the intervention were collected by means of focus group interviews, which were used to optimize the intervention (Aim 1). Quantitative data on teachers' appreciation were collected directly after they had engaged in the intervention and were used to compare the appreciation from the initial to more optimized versions of the trainings (Aim 2). Further, by means of repeated measures ANOVAs positive evolutions in teachers' belief in the utility of, confidence to apply and knowledge about the provided strategies across time were examined (Aim 3). Finally, teachers' adherence was evaluated by relying on

weekly online registrations of minutes and types of preventive strategies teachers had practiced during the past week (Aim 4).

Findings: Despite the relatively high initial appreciation scores (4.2 out of 5), the optimized versions of the trainings scored better on interaction, intelligibility, innovation, practical usefulness, and recommendation (Aims 1 and 2). Significant differences were found over time in terms of within-teacher changes in perceived utility of (4.05–4.73–4.48; $p < .001$), confidence to apply (3.75–3.96–4.26; $p < .001$) and knowledge about preventive strategies (2.49–3.53–3.39; $p < .001$; Aim 3). Finally, prospective registrations of teachers' adherence to the proposed strategies showed a mean time of 62.1 ± 48.6 min/week with a balanced distribution of the different strategies (Aim 4).

Conclusions: The present study developed an intervention that optimally fulfils the wishes and needs of the target population, namely PETs, and can readily be implemented in PET education programmes or CPD programmes for in-service PETs. Results of this pilot study are promising because teachers displayed increases in several relevant outcomes. Various suggestions are formulated on how to increase PETs' appreciation of CPD programmes.

Introduction

Secondary school physical education teachers (PETs) constitute an at risk group in terms of injury prevention, because they engage in a physically demanding job (e.g. long standing, carrying and lifting, demonstrating, aiding, and assisting; Sandmark et al. 1999), have an extensive history of sports participation and often still actively practice in sport themselves (either in competition or recreational). Moreover, PETs are often engaged as a coach in a sports club (Lemoyne et al. 2007). Due to this total package of physically active tasks, high injury prevalence rates are reported among PETs (Kovač et al. 2013; Lemoyne et al. 2007; Pihl, Matsin, and Jurimae 2002; Sandmark and Vingard 1999). Those injuries might damage PET's professional duties (e.g. being unable to demonstrate an exercise) and personal activities (e.g. inability to engage in leisure time activities). Therefore, it seems crucial to develop effective injury prevention

interventions that can be integrated in both physical education teacher education and continuing professional development (CPD) programmes for in-service teachers.

In the existing literature on injury prevention strategies, researchers have mainly focused on identifying effective preventive strategies (e.g. the effects of warm up, Soligard, Myklebust, and Steffen 2008; Malliou et al. 2007). However, professional development research (O'Sullivan and Deglau 2006) strongly suggests to focus not only on content (i.e. identifying effective strategies), but also on the delivery approach (e.g. interactive, practical). Yet, limited attention has been paid to the approaches used to deliver injury prevention interventions.

By integrating findings of effective injury prevention programmes and knowledge on effective approaches to delivering CPD (Aelterman et al. 2013; Armour and Yelling 2004), this study aimed to develop an injury prevention intervention that is well-appreciated by PETs. The underlying assumption is that teachers will have a greater willingness to implement a proposed strategy, if the intervention corresponds more closely to teachers' specific wishes and interests (Aelterman et al. 2013).

Previous studies have used two types of preventive strategies. Extrinsic preventive strategies alter aspects of the persons' environment, generally considered beyond the control of the person (e.g. providing a better sports floor in the gym; Meeuwisse 1994). Interventions using such an extrinsic preventive approach require a change in the school's environment, which was beyond the scope of the current study. Intrinsic preventive strategies intend to make changes related to the physical characteristics of the person (e.g. improving flexibility). At least seven intrinsic prevention strategies have been shown to be effective in previous work, these are (a) Warm up (Malliou et al. 2007; Soligard, Myklebust, and Steffen 2008), (b) Cooling down (Malliou et al. 2007), (c) Core stability training (Childs et al. 2010; McGill 2010), (d) Balance training (Cumps, Verhagen, and Meeusen 2007; Mc Guine and Keen 2006), (e) Functional strength training (Arnason et al. 2008), (f) Stretching (Amako et al. 2003; Pope et al. 2000), and (g) Correct performance (Scase et al. 2006).

With regard to warm up activities studies among 13–17 years old football players (Soligard, Myklebust, and Steffen 2008) and adult aerobic instructors (Malliou et al. 2007) showed that activities such as slow speed running, strength, balance, and agility exercises, and high speed running can lower the risk for any type of injury. Similar positive findings have been reported for cooling down (Malliou et al. 2007) and functional strength training (Arnason et al. 2008). Training core stability has been shown to reduce low back disorders (Childs et al. 2010; McGill 2010), while balance training is particularly effective in reducing ankle sprains (Cumps, Verhagen, and Meeusen 2007; Mc Guine and Keen 2006). With respect to the impact of stretching, reductions in both muscle/tendon injuries and low back pain have been found when military recruits engaged in stretching exercises for 20 minutes before and after their training sessions (Amako et al. 2003). Finally, teaching landing skills in a sample of football players in a preseason training intervention reduced the chance of sustaining an injury during the following season (Scase et al. 2006). Apart from these studies that have focused on specific intrinsic prevention strategies, it has been demonstrated that multifactorial intrinsic injury prevention interventions can lower the occurrence of musculoskeletal injuries in sports active populations (Parkkari, Kujala, and Kannus 2001). Therefore, in order to prevent overall injuries in PETs, each of the identified effective intrinsic strategies can not only be implemented separately, but also in a balanced combination. So far, no multifactorial injury prevention intervention in a population of PETs has been systematically developed.

Although the above studies indicate positive effects in response to a number of identified intrinsic preventive strategies, one consistent finding is participants' lack of continued adherence to the proposed preventive strategies (Myklebust et al. 2003; Verhagen et al. 2010). Adherence might become an even more prominent issue for PETs, as it is not that common for PETs to engage in injury prevention strategies such as a warm up activity prior to teaching. When developing an intervention for PETS, Aelterman et al. (2013) found that teachers' intention to apply the proposed strategies in their own practice was positively correlated with the global appreciation of the intervention. More specifically, these authors showed that teachers' appreciation of the intervention in terms of its intelligibility, interactivity, innovativeness, interestingness,

essentiality, and practical usefulness related to their intention to engage in the proposed strategies. As such it was suggested that increasing teachers' appreciation of an intervention might increase teachers' adherence to the proposed strategies. Moreover, according to the self-determination theory (SDT, Deci and Ryan 2000), the willingness to engage in the proposed strategies will be higher when participants understand the personal usefulness of the preventive strategies and feel confident and competent to apply the strategies (Aelterman et al. 2013). Apart from these two parameters (utility and confidence), improvement in knowledge is also suggested to positively affect adherence (Wang, Lin, and Huang 2012).

It has furthermore been suggested that to be able to put the theory into practice, it is crucial to connect with teachers' everyday practice (Armour and Yelling 2004; Garet et al. 2001), to create opportunities for teachers to interact with each other and share ideas (Armour and Makopoulou 2012; O'Sullivan and Deglau 2006), to bring together teachers from different physical education (PE) departments (Armour and Makopoulou 2012; Garet et al. 2001) and to allow teachers to express disagreements with the content of the programme (O'Sullivan and Deglau 2006). These principles are also consistent with the ideas of SDT, which suggest that a CPD provider should try to deliver the intervention in a way that supports the participants' basic psychological needs for relatedness, competence, and autonomy to promote teachers' willingness to engage in the proposed strategies. To support teachers' need for relatedness (i.e. the experience of closeness, trust, or friendship in relationships with others; Baumeister and Leary 1995), the CPD provider can allow interaction, and can try to create a positive atmosphere among the participants. To support teachers' need for competence (i.e. feelings of success and effectiveness; White 1959), it is crucial to provide attainable exercises. Teachers' need for autonomy (i.e. a sense of volition and psychological freedom when engaging in an activity; Deci and Ryan 2000) can be nurtured by providing choices in the exercises.

Given the above findings, it seemed crucial, prior to conducting a large-scale intervention study, to systematically develop an intervention, that is well-appreciated by PETs in terms of content and delivery approach that allows teachers to understand the usefulness of the proposed strategies, and to build knowledge and competence. More

specifically, the first aim of this study was to systematically optimize an injury prevention intervention for PE teachers, based on teachers' qualitative evaluation of the intervention. The second aim was then to quantitatively investigate whether the appreciation (i.e. in terms of its intelligibility, interactivity, innovativeness, interest, essentiality, and practical usefulness) of the injury prevention intervention was higher after it was optimized. The third aim involved examining whether participation in the injury prevention intervention resulted in positive changes in teachers' perceived utility of, and confidence to apply the proposed preventive strategies, as well as their knowledge about these strategies, three variables that have shown to relate to behavioural change and adherence (Aelterman et al. 2013; Wang, Lin, and Huang 2012). And finally, we also aimed to describe teachers' adherence to the proposed preventive strategies while they were engaging in the intervention.

Methods

Design

To obtain an optimization of the present injury prevention intervention, the study relied on a mixed method design (Kevinson and Onwuegbuzie 2004), where both qualitative and quantitative data were collected. The major advantage of this combination is that it enables to (a) identify quantitative evolutions in teachers' appreciation of the intervention and (b) to obtain a deeper understanding of the reasons underlying these changes. Table 1 gives an overview of the research questions, related to the measurements and timing, analysis, and limitations to provide better insight in the different aims and related methods.

Table 1. A structured overview of the study

Research Question	Design: Measurements and timing	Analysis	Limitations
1) Optimization of the intervention			
Can we optimize an injury prevention intervention [1] based on teachers' qualitative evaluation of the intervention through cycles of implementation, evaluation and optimization?	Focus groups were conducted after each training	NVIVO (deductive) (transcripts of the focus groups)	
2) Appreciation of the optimized intervention			
Are the appreciation scores higher among teachers who received a more optimized version of the intervention?	Inter subject comparison After each training, the teachers filled out an appreciation questionnaire	One-way ANOVA with post hoc tests (A-A'-A") Independent samples T-test (B-B')	Different groups of teachers are compared over time, there might be confounding factors
3) Changes in teachers' outcomes after having engaged in the intervention			
Do teachers find the preventive strategies more useful, do they have more confidence to apply the strategies and do they improve in knowledge about the strategies after having engaged in the intervention intervention?	Pre (before training A; Feb-Mar), inter (before training B; Apr-May) and post (June) intra subject measurements were collected concerning the usefulness, confidence and knowledge about the preventive strategies.	Repeated measures ANOVA	The same subjects are compared, but received different iterations of the intervention, there was no control group to compare with
4) Adherence to the strategies			
How much time do teachers spent weekly on the provided preventive strategies and which kind of preventive strategies do they apply while they were engaging in the intervention?	Descriptive prospective: Weekly (after receiving training A in February/March till the last week of June) the teachers registered the amount of minutes and kind of preventive strategies they applied.	Descriptive statistics	No pre-test to compare with, no control group

[1]The intervention consisted of two trainings (A and B), which were delivered to small groups of teachers (A-A'-A" and B-B').

Participants

Twenty PETs (13 men, 7 women; mean age: 42.1 ± 12.17 years) from nine different secondary schools in Flanders (Belgium) voluntarily participated in the study. Among them, 11 (55%) had obtained a bachelor's degree in PE and 9 (45%) achieved their master's degree.[1] Teaching experience ranged between 6 months and 36 years, with an average of 17.5 years, and teachers were teaching students between 12 and 18 years old at the time of data collection. The teachers were involved in different types of education; academic (i.e. general education preparing students for higher education), technical (i.e. a less theoretical and practical approach), or vocational education (i.e. preparing children for the labour market immediately after secondary school). In addition to teaching, nine teachers were also active as a trainer in a sports club.

During the course of the study, three of the twenty teachers dropped out (15%) and only participated in training A (see Intervention). Specifically, one teacher found the exercises too stressful for his joints and he no longer saw the use of the intervention at his age (57 years). In addition, two teachers could not participate in training B because of practical reasons, but they did complete all questionnaires.

Procedure and instrumentation

The ethical committee of Ghent University Hospital in Belgium approved the protocol of the study. All 20 participants in the present study received an information letter and signed an informed consent form.

Focus groups and optimization of the intervention (Aim 1)

As for the systematic optimization of the injury prevention intervention (Aim 1), PETs were given the opportunity to share their opinions, thoughts, and suggestions immediately after attending a training session, and to discuss them in a focus group interview. As such, teachers could better clarify their thoughts and feelings and were given the opportunity to complement each other's remarks. Based on teachers' feedback, the trainings were optimized. Training A was optimized in three cycles, that is, eight teachers received and evaluated the initial version (training A), seven teachers

received and evaluated a more optimized version (training A'), and finally a group of five teachers received and evaluated the most optimized version (training A"). As for training B, the same twenty PETs (drop-out of three PETs) were divided into two groups, with nine teachers receiving and evaluating the initial version of training B, and eight teachers receiving and evaluating an optimized version (training B').

Each focus group was held with five to eight teachers and lasted for approximately 30–40 minutes. To obtain an interview without restraints, the moderator of the focus group was not the provider of the trainings. The moderator started the focus groups with explaining both the purpose and the procedure of the focus group interview. To make changes according to the suggestions from the focus groups, brief notes were taken during the interview (transcripts were made later) and each focus group was also audio- and videotaped. Each focus group had a similar route of questions reflecting the same dimensions of appreciation as in the appreciation questionnaire (see below; Krueger 1998; Morgan 1996; Morgan and Krueger 1998). Examples of questions from the moderator were: What was your overall impression of the training? Did you find the theoretical part innovative/easy to understand/interactive/interesting/…? Why?

Appreciation questionnaires (Aim 2)

The second aim was to quantitatively investigate whether the appreciation of the injury prevention intervention was higher after it was optimized. To do so, teachers' appreciation of the intervention was measured, immediately after each training (A or A' or A" and B or B'), based on an existing appreciation questionnaire developed by Aelterman et al. (2013). The questionnaires were filled out prior to engaging in the focus groups.

The constructs of the questionnaire are shown in Table 2 and represent the acceptability (interaction, innovation, interest, intelligibility, and essentiality), practical usefulness, and extent of recommendation to colleagues. A part on the structure, clearness, and added value of the didactical posters was added in order to have additional appreciation scores on the didactical posters. The PETs evaluated all constructs on a five-point Likert scale (1 = totally disagree, 2 = disagree, 3 = neutral, 4 = agree and 5 = totally agree). If

more than one question was assessed per construct (e.g. interest was assessed by means of the items 'fascinating and interesting' and 'increased my interest in the subject') a mean score was calculated.

Table 2. The constructs of the appreciation questionnaire

Constructs	
Acceptability	
Intelligibility	Part I/II/III/IV/V was easy to understand
	Part I/II/III/IV/V showed a logical consistency
Interaction	Part I/II/III/IV/V was sufficiently interactive
Innovation	Part I/II/III/IV/V was innovative
Interest	Part I/II/III/IV/V was fascinating and interesting
	Part I/II/III/IV/V has increased my interest in the subject
Essentiality	Part I/II/III/IV/V was an essential part of the training
Didactical posters	
Structure	The didactical posters are well structured
clearness	The didactical posters are clear
Added value	The didactical posters have an added value in this training and the entire intervention
Practical usefulness	The exercises are practically useful
Recommendation	I would recommend training A/B to another colleague

Usefulness, confidence, and knowledge about the strategies (Aim 3)

The third aim of the present study involved investigating whether participation in the injury prevention intervention resulted in positive changes in teachers' perceived utility of, and confidence to apply the proposed preventive strategies, as well as their knowledge about these strategies. These three outcomes were assessed three times; pre (before training A; Feb–Mar), inter (before training B; Apr–May), and post (June). As teachers were divided in smaller groups, the scores on these three outcomes were gathered after receiving different iterations of the intervention (A or A' or A" and B or B').

To determine perceived utility of the different preventive strategies, one question per preventive strategy was scored on a five-point Likert scale from 1 (totally useless) to 5 (totally useful). Additionally, one question to be rated on a scale from 1 (totally disagree) to 5 (totally agree) per preventive strategy was used to assess confidence to apply the strategies. Intra-rater reliability of these sets of questions was tested in 18 PETE

students and all outcomes scored average to excellent (all ICCs > 0.40) according to the Fleiss reliability scale (Fleiss 1986). The set of questions measuring knowledge included 13 multiple-choice questions relating to the different preventive strategies and had only one correct answer. For each of the three sets of questions a mean score on five was calculated.

Adherence to the strategies (Aim 4)

The final aim of the present study was to describe teachers' adherence to the proposed preventive strategies while they were engaging in the intervention. After having received training A (or A' or A"), teachers started to register their preventive behaviour in terms of minutes and types of strategies weekly. To do so, every Wednesday teachers received a reminder by email including a hyperlink to the online registration form. This online registration ended at the end of the school year (last week of June), after teachers had engaged in the entire intervention.

Intervention

Design of initial intervention. Based on the thorough review of the literature on injury prevention strategies, and lessons learned from studies on approaches to effective CPD programmes, including knowledge on SDT-based approaches to delivering interventions, a first version of the intervention was set up. Before actually delivering the intervention, seven PETs were voluntarily questioned in advance by means of a focus group interview on the expectations and suggestions they would have if they would participate in an injury prevention programme. Teachers could indicate what would be the barriers to really implement the proposed preventive strategies, which kind of intervention they had in mind and how they expected the delivery approach to be. This preliminary focus group interview revealed that all PETs had previously experienced some kind of injury in their career. The main reasons for these injuries were overload and repetition. One of the teachers cited 'I think it is the combination of different factors that often causes problems'. Given the relevance for all of them, they were all interested in the topic at hand and wanted to learn as much as possible about it. The two biggest barriers to really implement preventive strategies were the lack of time and not finding the will to get

started. Teachers suggested they would be motivated to apply injury prevention strategies through participation in a group event, if they would receive an intervention that can be applied in daily life, or when they would be injured. Further, the participants suggested to develop a website with all the information delivered during the training. Social media didn't seem the preferred communication channel and didactical posters were suggested.

Development and optimization. The multifactorial intervention focused on seven preventive strategies: (1) correct performance, (2) warm up, (3) cooling down, (4) stretching, (5) core stability training, (6) balance training, and (7) functional strength training. These seven preventive strategies were provided in five main parts, spread over two training days. The first training day (Training A) was organized in February–March and consisted of a theoretical part (Part I) and a practical part (Part II). The second training day (Training B) took place in April–May and encompassed three practical parts (Part III, IV, and V). The five parts (I–V) of the intervention, spread over two trainings (A and B), encompassed all seven preventive strategies. With respect to the delivery approach, the trainer tried to nurture teachers' needs for autonomy, competence, and relatedness (Deci and Ryan 2000) in order to motivate the teachers to engage in the proposed strategies (Aelterman et al. 2013). Moreover, according to the findings in the CPD literature, teachers from different schools were brought together (Armour and Makopoulou 2012; Garet et al. 2001) and opportunities were created for teachers to interact with each other and to share ideas (Armour and Makopoulou 2012; O'Sullivan and Deglau 2006).

The trainer in this study (28 years, male) had extensive teaching experience with diverse audiences (e.g. university PETE students, secondary school students, and PE teachers) and was very familiar with the contents of effective injury prevention interventions due to his own doctoral research in the field of sports injury prevention in PETE students (Goossens et al. 2015a). As we aim to describe how the intervention was systematically developed throughout this process (of implementation, evaluation, and optimization), we start with an overview of the initial version of the five parts of the training, in terms of content and delivery approach, that were gradually optimized by continuous adjustments after each training.

Training A. In Part I (1h15), all seven preventive strategies were explained in a theoretical way, with the aim of informing the teachers about the value and efficacy of the proposed strategies, and increasing their knowledge about these strategies. A PowerPoint presentation was used and teachers received the handouts in a booklet. As for the delivery approach, this theoretical part started with an interactive introduction where teachers got to know each other, followed by communicating the background of the preventive strategies and allowing teachers to ask questions and to interact with the trainer.

In Part II (1h45), the PETs had the opportunity to practice and experience exercises concerning the neutral position of the spine (e.g. maintain and correct neutral position while standing, in the supine position and on hands and knees support), core stability (e.g. learning to (un)consciously contract deep abdominal and back muscles while doing the big three; side bridge, bird dog, and curl-up) and functional strength training (e.g. squats, lunges, push-up variations, etc.). Didactical posters were used to illustrate the core stability and functional strength training exercises and demonstrated three different levels (one is the easiest and three the hardest; for an example see http://figshare.com/articles/Prone_bridge_three_levels/1312908). The easiest exercises were designed in a way that all PETs would be able to experience success, and more difficult exercises were provided to sufficiently challenge each of the PETs. In this part, the delivery approach included working in pairs to correct each other's spine position by trying to contract and feel their own deep abdominal and back muscles after having been exposed to a good demonstration and by teaching the preventive strategies to each other by using the didactical posters.

Training B. In Part III (30 min) teachers practiced a good warm up, namely a general cardiovascular part followed by a specific warm up, including dynamic stretching exercises (see https://www.youtube.com/watch?v=_sBQNWBkbus) and inducing light sweat. This part was in a group session instructed by the trainer, in which teachers were invited to propose other exercises or to discuss the proposed exercises.

Part IV (1h30) of the training included suggestions for teachers on how they could easily implement the preventive strategies into their daily life. For instance, teachers were

suggested to peel an apple while standing on one leg, a good sleeping position was practiced on a tick tumbling mat, and examples of dynamic sitting postures were provided. This part of the training was practiced independently by the PETs, based on the instruction in the booklet.

Lastly, Part V (30 min) consisted of a cooling down with static stretching (see https://www.youtube.com/watch?v=rQ2aBGAEUSI&feature=youtu.be). The delivery approach was similar to part III of the intervention. In addition to the last three parts, informative videos of the warm up, cooling down and 'an injury preventive day of a PET' were shown to the teachers. These videos could be consulted on the training website afterwards.

Data analysis

First, in order to optimize training A to A', training A' to A" and training B to B' (Aim 1), qualitative data from focus group interviews were used. The focus group interviews were transcribed by two independent researchers based on the audio- and videotapes, and thematic content analysis (Aronson 1995) in NVIVO Version 9.0 (Gibbs 2002) was used to organize the quotes by category (e.g. barriers to implement the preventive strategies). Some of the most relevant quotes, namely the quotes cited by the majority of those attending a focus group interview, were added to the results. For example, five out of eight PETs in the first focus group interview cited that the theoretical part was very welcome and essential.

As for the second aim, the quantitative data of the appreciation questionnaires were used to investigate if teachers who received a more optimized version of the training also appreciated the training more. To investigate differences in appreciation scores between training A (n = 8), A' (n = 7) and A" (n = 5), a one-way ANOVA with post hoc tests was used. An independent sample t-test was used to compare the appreciation scores of training B (n = 9) and training B' (n = 8). Third, to evaluate within-teachers changes in perceived utility of, confidence to apply and knowledge about preventive strategies (Aim 3), repeated measures ANOVAs were used to compare pre (before training A or A' or A"; Feb–Mar), inter (before training B or B'; Apr–May), and post (in

June) measurements. Finally, to report actual engagement in the preventive strategies in terms of time spent weekly and the type of strategies applied (Aim 4), descriptive statistics were used. For all quantitative analyses, we used SPSS Statistics 21 (IBM SPSS Statistics for Windows, Version 21.0. Armonk, NY: IBM Corp.).

Results

Focus group interviews (Aim 1)

The qualitative evaluation of the intervention, by means of focus group interviews, led to following changes in part I from training A to A': starting with a clear overview of the topics that will be addressed, using more intelligible words (e.g. Dutch instead of Latin indications of the muscles), and ensuring that everybody understands the basic elements by asking questions to the participants (e.g. 'Can anyone explain the difference between static and dynamic stretching with an example?'). From training A' tot A", this theoretical part was made more enjoyable and attractive by adding quiz questions and giving opportunities for practical try outs such as standing on one leg with the eyes closed. Due to the initial use of the principles of the SDT and the latter changes, teachers engaged with great pleasure in the theoretical part (see quote below).

> In the beginning, during completion of the questionnaire, I did not have much enthusiasm, but once the theoretical part started I was immediately motivated thanks to the use of different interactive methods. (training A')

The most important changes in part II from training A to A' were: providing mirrors in the room in order to practice the exercises while controlling the body posture, showing some important exercises per body part in the beginning of this part while stressing an important aspect of the exercise and also using more intelligible words on the didactical posters. The changes from training A' to A" consisted of a big makeover of the didactical posters (e.g. adding levels, active muscle groups, frequencies, organization of images, and text), a better explanation of the delivery approach during the training (teachers teach each other) and prolonging the duration of this first practical part. The following quote cited during the focus group interview of training A', leaded to some major changes in didactical posters.

> The didactical posters were not always very clear, especially with the exercises I am not familiar with. Pictures from different angles of the shoulder positions would be helpful. (training A')

In between training B and B', one change was made to this part of the intervention, namely three endurance tests were added, because the focus groups showed that teachers wanted some kind of indication about their muscular endurance to know which of the proposed exercises they needed to perform the most. The endurance tests consisted of a lateral trunk musculature test in side bridge position, a trunk flexor endurance test in a sit-up posture and a trunk extensors test in the 'Biering-Sorensen position' (McGill 2002). The great appreciation of the exercises in training B is reflected in the next quote, during the focus group interview of training B. 'The practical exercises were innovative, diversified and practically feasible' (training B).

After both trainings were delivered, all teachers had the opportunity to give suggestions with regard to the sequence in which the different parts of the intervention were sequenced. First, teachers indicated that it would be better to spread the didactical posters of the functional strength part over the entire intervention. Specifically, providing the didactical posters all together in a single session caused a feeling of overload in some teachers. They also suggested to include the three endurance tests much earlier, so PETs could self-select the most personally relevant exercises (e.g. 'I will try to do more strengthening exercises for the back, because those muscles are too weak compared to my abdominals'). Similarly, they suggested showing the video on 'exercises implementable in daily life', much earlier in the intervention to increase adherence. Finally, sending reminders (e.g. bimonthly reminder e-mails with additional exercises) about the proposed strategies were suggested to be effective if the intervention would be given over a longer period of time.

Appreciation scores (Aim 2)

Training A-A'-A"

The initial appreciation scores of the entire training A (score of 4.2 out of 5) were high, and generally all scores remained high across different groups of teachers and after adaptations had been made (A: 4.2; A': 4.1; A": 4.5). A few scores even significantly improved. The score of practical usefulness of the exercises changed significantly from A (3.88) to A" (4.80; p = .016). The score for recommendation to other colleagues changed significantly from A' (4.00) to A" (4.80; p = .037). More details about the various parts and different constructs are provided in Table 3.

Table 3. Mean appreciation scores, on a scale from one to five, for training A, A' and A".

Constructs	Mean A	Mean A'	Mean A''	F	p
I. Theoretical Part					
Intelligibility	4.19_{a}	4.36_{a}	4.60_{a}	1.764	.201
Interaction	4.13_{ab}	4.00_{a}	5.00_{b}	3.185	.067
Innovation	4.13_{a}	3.57_{a}	3.40_{a}	2.140	.148
Interest	4.13_{a}	4.07_{a}	4.50_{a}	0.929	.414
Essentiality	4.38_{a}	4.14_{a}	4.40_{a}	0.384	.687
II. Functional strength training					
Intelligibility	4.07_{a}	4.29_{ab}	4.50_{b}	2.636	.102
Interaction	4.29_{a}	4.29_{a}	4.60_{a}	0.718	.503
Innovation	4.00_{ab}	3.29_{a}	4.40_{b}	4.704	.025
Interest	3.86_{a}	4.07_{a}	4.30_{a}	0.858	.443
Essentiality	4.71_{a}	4.57_{a}	4.80_{a}	0.330	.724
Didactical Posters					
Structure	4.29_{a}	4.29_{a}	4.40_{a}	0.095	.910
Clearness	3.71_{a}	4.14_{a}	4.30_{a}	1.139	.345
Added Value	4.43_{a}	4.43_{a}	4.80_{a}	0.962	.403
Entire training A					
Practical Usefulness	3.88_{a}	4.14_{ab}	4.80_{b}	5.004	.020
Recommendation	4.25_{ab}	4.00_{a}	4.80_{b}	3.756	.045

$_{ab}$: same letter = no significant differences; different letter = significant differences

Specifically with regard to Part I, that is the theoretical part, high initial appreciation scores on the different constructs were found, but yet the interaction score evolved positively with a trend towards significance from A' (4.00) to A" (5.00; p = .074).

For part II, in which neutral position of the spine, core stability, and functional strength exercises were provided with the use of didactical posters, intelligible scores became

higher with a trend towards significance from A (4.07) to A" (4.50; p = .087) and innovation scores increased significantly from A' (3.29) to A" (4.40; p = .024). Also the score of the structure, clearness, and added value of the didactical posters increased throughout the different trainings, but none of these scores changed significantly.

Training B-B'

While developing training B a lot of suggestions given in the focus groups of training A were implemented already. This resulted in a well-appreciated training B (4.2 on a maximum score of 5) that required only one main change (adding three endurance tests) from training B to training B'. No significant differences in appreciation were noticed between teachers that engaged in training B and teachers that engaged in training B' (Table 4).

Table 4. Mean appreciation scores, on a scale from one to five, for training B and B'.

Constructs	Mean B	Mean B'	F	p
III. Warm up with dynamic stretching				
Intelligibility	4.63	4.62	1.853	0.194
Interaction	4.75	4.62	1.264	0.279
Innovation	3.25	3.62	0.201	0.660
Interest	4.25	3.81	0.263	0.616
Essentiality	4.75	4.15	0.414	0.530
IV. Exercises implementable in daily life				
Intelligibility	4.38	4.08	0.447	0.514
Interaction	4.25	4.08	0.184	0.674
Innovation	4.00	3.77	0.001	0.976
Interest	4.00	3.85	0.089	0.770
Essentiality	4.25	4.15	0.414	0.530
V. Cooling down with static stretching				
Intelligibility	4.38	4.15	0.458	0.509
Interaction	4.00	3.82	0.045	0.835
Innovation	4.00	3.00	3.025	0.102
Interest	3.56	3.77	1.890	0.189
Essentiality	4.25	3.92	0.072	0.792
Entire training B				
Practical Usefulness	4.75	4.38	1.264	0.279
Recommendation	4.75	4.15	0.414	0.530

Usefulness, confidence, and knowledge about the strategies (Aim 3)

The perceived utility of the proposed preventive strategies evolved significantly from a mean score of 4.05–4.73 ($p < .001$) from pre- to inter- and decreased slightly ($p = .002$) to 4.48 at post-test. The post-test score was still significantly better than pre score ($p < .001$).

The confidence of PETs in correctly practicing the preventive strategies increased systematically and significantly from 3.75 at pre-test to 3.96 ($p = .016$) at inter, and 4.26 at post-test ($p = .003$). Posttest scores were also significantly better than pre score ($p < .001$).

The PETs started with an average knowledge score of 2.49 out of 5, it increased significantly ($p < .001$) to a score of 3.53 and remained stable (3.39; $p = .519$). Post score was also significantly better ($p < .001$) than pre score.

Adherence to the strategies (Aim 4)

The 17 PETS who completed the whole intervention, spent on average 62.1 ± 48.6 min/week on the proposed strategies. Overall, men (n = 10; 74.5 ± 57.6 min/week) practiced more minutes per week than women (n = 7; 44.3 ± 26.6 min/week). Moreover, the following distribution reflects the percentage of time teachers spent in each of the preventive strategies: warm up (20.3%) and core stability training (17.1%) being ranked as the most frequently applied strategies, followed by functional strength training (14.4%), balance training (14.0%), and static stretching (13.7%). Dynamic stretching (11.2%) and cooling down (9.3%) were the least implemented strategies.[2]

Discussion

It is known that secondary school PETs constitute an at risk group in terms of injury prevention (Goossens et al. 2015b; Lemoyne et al. 2007; Pihl, Matsin, and Jurimae 2002; Sandmark and Vingard 1999). Indeed, PETs in the present study also reported a lot of injuries with 17 of the PETs having had one or more injuries in the six months prior to the start of the study. These findings confirm that effective intrinsic injury prevention interventions are strongly needed in this group. While insights into successful injury

prevention strategies are available from studies in other populations such as adolescents, athletes, military populations, and health-care workers (Abernethy and Bleakley 2007; Garg and Owen 1994; Jones and Knapik 1999; Paterno et al. 2013), participants' lack of adherence to the proposed strategies has been identified as a crucial problem (Myklebust et al. 2003).

The current study aimed at contributing to the field of injury prevention in PETs, thereby taking into account CPD- and SDT-based suggestions to not only focus on content, but also on delivery approach (O'Sullivan and Deglau 2006) to enhance adherence. Specifically, the content of the initial version of the intervention was based on effective preventive strategies (e.g. Amako et al. 2003; Arnason et al. 2008; Soligard, Myklebust, and Steffen 2008). The delivery approach was based on the SDT (Deci and Ryan 2000) and was targeted at fulfilling participants' psychological needs for autonomy, competence, and relatedness throughout the intervention (Aelterman et al. 2013). For example, the training included practices related to teachers' everyday life (i.e. competence; Armour and Yelling 2004; Garet et al. 2001), provided opportunities for teachers to express disagreements with the content of the intervention (i.e. autonomy) and to interact with other participants (i.e. relatedness; Armour and Makopoulou 2012; Armour and Yelling 2007; O'Sullivan and Deglau 2006).

After we had developed an intervention that accounted for previous findings on content and way of delivery, we systematically optimized the injury prevention intervention for PETs, based on teachers' qualitative evaluation of the intervention (Aim 1). In the initial focus group, PETs suggested that the two biggest barriers to implement the preventive strategies would be lack of time and not finding the will to get started. In the current study, the 'lack of time' barrier was solved by offering examples of small exercises that are easily implementable in daily life. Finding the will to get started was stimulated by nurturing teachers' needs for autonomy, relatedness and competence, which presumably fostered their autonomous motivation (Deci and Ryan 2000). For example, the teachers had a better belief in the utility of the different preventive strategies after receiving the theoretical background, and due to the novel delivery approach (e.g. including competitive elements during the practical exercises) teachers might feel more autonomous motivated to engage in the strategies.

In the subsequent focus group interviews teachers reported that they were familiar with most of the preventive strategies, but this was not deemed problematic. Teachers preferred a repetition of what they already knew over receiving an overload of new knowledge and indicated they did not frequently (enough) engage in all of these strategies. During the focus groups PETs reported to practice warm up, cooling down, and stretching most frequently, but that other strategies such as functional strength training, core stability, balance, and correct landing techniques were almost never used. Consequently, PETE programmes might consider giving more attention to the latter preventive strategies and promoting the use of different preventive strategies should be pursued (Parkkari, Kujala, and Kannus 2001). Concerning the delivery approach, teachers indeed emphasized they had become interested and motivated instantly when interactive methods were used and they loved that they could remain in their role as a teacher in the practical part. Specifically, rather than the trainer delivering the exercises to the teachers, teachers could teach each other by means of the didactical posters. In the study of Myklebust et al. (2003) physical therapist were selected to function as supervisors in order to improve the adherence in athletes. As such approaches would make future large-scaled implementation of the intervention impossible, weekly reminders (e.g. providing additional information) and an interactive website could be good alternatives.

Overall, teachers appreciated the content of the intervention and that it was delivered through a combination of a theoretical component and practical exercises. Moreover, the didactical posters received a lot of positive attention in the practical parts of the intervention as teachers found it a very useful tool to explain how to do the exercises correctly. The didactical posters really provided opportunities for interactive learning, which can also explain their success (Armour and Makopoulou 2012). As a result of the CPD intervention, some teachers even decided to use these didactical posters in their secondary school PE lessons, and the suggestion was given by PETs to use these posters in PETE programmes. In addition, teachers experienced the endurance tests as an essential part of the CPD intervention. Hence, including such tests in PETE programmes might help to prevent injuries in pre-service teachers because they are stimulated to train the muscles that need most training. Overall, as for the first aim we can conclude

that we managed to design an intervention programme that effectively fulfilled the wishes and needs of the PETs, and that can readily be implemented in PETE programmes or CPD programmes for in-service teachers.

As Aelterman et al. (2013) found that teachers' intention to apply the proposed strategies in their own practice was positively correlated with the global appreciation of the intervention, it was suggested that increasing teachers' appreciation of an intervention might increase teachers' adherence to the proposed strategies. Therefore, the second aim in this study was to quantitatively investigate whether the appreciation of the injury prevention intervention was higher after it was optimized (Aim 2). Initial appreciation scores were already high in the present study and they remained high or slightly improved after optimization. From training A (Theoretical part and Functional strength training) and training B (Warmup with dynamic stretching, Exercises implementable in daily life and Cooling down with static stretching), the warm up with dynamic stretching and cooling down with static stretching were perceived the least innovative. These findings perhaps suggest that PETE programmes emphasize these strategies throughout their education programme. Higher innovation scores (i.e. the extent to which PETs found a part innovative) were given to the part in which exercises implemented in daily life could be practiced. In this part, small exercises on core stability, balance, and functional strength training were implemented as well. The high innovation scores in this part reinforce the need for more attention on core stability, balance, and functional strength training in PETE programmes. PETE programmes form the basis for learning the proper prevention strategies for a future career, and therefore should contain the most relevant and up to date findings. A similar instructional video for pre-service PETs ('exercises implementable in the daily life as pre-service PET') could be developed, so that they are stimulated to already engage more frequently in preventive strategies throughout their educational programme. This is in line with the CPD literature, suggesting that teachers' everyday practice should be included in the intervention (Armour and Yelling 2004; Garet et al. 2001).

It has also been suggested in the CPD literature (except for Aelterman et al. 2013) that teachers tend to not appreciate a lot of theory in CPD interventions. This part of the training was also considered as less innovative, but still was found essential in the

present study. We hypothesize that it is not the theoretical background in itself that is often disliked by teachers, but the fact that theory is sometimes delivered in a non-interactive and non-applied way. As such, it is reasonable that the use of a more motivational, interactive, and applicable introduction of the theory probably reduces the barriers for PETs to engage in CPD interventions. Indeed, within the CPD-literature, it has been suggested that opportunities for interactive learning are crucial to obtain positive effects (e.g. Armour and Makopoulou 2012; Armour and Yelling 2004). Throughout the different versions of the intervention in the present study we increased the interactivity of the theoretical component as a result of the teachers' suggestions. To illustrate, the theoretical part started with giving teachers opportunities to share experiences with other teachers, there was room for discussion, quiz-like questions were included, and small practical teasers were added in the theoretical part, which stimulated the teachers' engagement with the theory. The optimization process led to the development of an interactive theoretical part which teachers appreciated and found coherent.

As for the third aim of the study, a positive change was observed in perceived utility, confidence to apply and knowledge about the proposed preventive strategies. Also, teachers who had engaged in the initial version of the intervention perceived the proposed strategies as more useful and improved their knowledge about the strategies. Further, teachers' confidence to apply the strategies increased over time. These findings are promising, because adherence to the proposed strategies is suggested to be higher when participants understand the personal usefulness of the preventive strategies, feel confident and competent to apply the strategies (Aelterman et al. 2013), and have good knowledge about injury prevention (Wang, Lin, and Huang 2012). It is well known that better adherence to the suggested preventive strategies results in lower injury incidence.

The final aim of this study involved describing teachers' adherence to the proposed preventive strategies while they were engaging in the intervention (Aim 4). Throughout the intervention we tried to nurture teachers' psychological needs for autonomy (i.e. experiencing a sense of volition and psychological freedom when engaging in an activity and being the initiator of one's own actions; Deci and Ryan 2000), relatedness (i.e. the experience of closeness, trust, or friendship in relationships with others; Baumeister and

Leary 1995) and competence (i.e. feelings of success when trying to master a task or exercise; White 1959). By nurturing these needs as much as possible (Aelterman et al. 2013; Gorozidis and Papaioannou 2014), we aimed at stimulating the development of autonomous motivation to engage in the proposed strategies. In the present study we could see that teachers made use of all seven preventive strategies and used the different strategies in a balanced way, so the application of preventive strategies became more diverse than only focusing on warm up and cooling down. So, interventions should be designed based on SDT principles in order to enhance adherence and thereby enhance the effect of the intervention on reducing injuries.

Limitations and future directions

A first limitation relates to the small group of participants. Only 20 teachers participated in this research. Although this provided valuable qualitative information to optimize the intervention, quantitative analyses should be interpreted with caution given this small sample size. Also, since the teachers voluntarily participated in the study and were not randomly recruited, different results on the appreciation of the training might have been obtained if teachers were participating in an obligatory CPD programme. Further, the small sample size made it hard to find significant differences in the appreciation scores as comparisons were made between small groups, and appreciation scores of the first group were already high. Nevertheless, despite the small group, some positive changes were obtained. Specifically, the perceived utility of the proposed preventive strategies evolved significantly from pre to inter and decreased slightly at post-test. The slightly decrease from the inter- to post-test is perhaps because in training B focus was on learning how to perform and implement the strategies, while in training A the theoretical background with indications of the advantages, which is the rationale of the intervention, intended a higher perceived utility. The post-test score was still significantly better than pre score ($p < .001$).

Another limitation is that in the repeated measures concerning utility of, confidence to apply, and knowledge about the preventive strategies, teachers received different iterations of the trainings (e.g. one teacher received training A and B, while another received training A' and B'). Also, in this study no control group was included to compare

the results with, so although some of the relevant outcome measures increased over time, no conclusions could be made yet with regard to the effectiveness of the intervention. The next step to test the effectiveness of the optimized intervention is in a randomized controlled trial over a longer period of time with larger samples (e.g. Baker et al. 2001).

Lastly, the appreciation questionnaire used in the present study was set up and used only in the study of Aelterman et al. (2013). These authors reported good internal consistencies in the different constructs (Cronbach alpha ≥ 0.7), except for interaction (0.55) and essentiality (0.36), which might raise questions about the reliability and validity of this scale. Although future research could refine the appreciation questionnaire, the results were considered reliable as they are fully in line with the participants' quotes of the focus group interviews.

Conclusion

This study succeeded in the aim of developing an intervention that met the wishes and needs of the target population, namely PETs. In addition to the literature, our results showed that teachers prefer repetition of what they know over receiving an overload of new knowledge; teachers appreciated the combination of theoretical components with practical exercises; they prefer practical exercises that are easy implementable and match their everyday practice; the two biggest barriers to start implementing preventive strategies were 'a lack of time' and 'not finding the will to get started'. Moreover, while developing a CPD intervention one should not only focus on content but also on the delivery approach. In this study the SDT was implemented and resulted in increases of several relevant outcomes such as perceived utility of, confidence to apply, and knowledge about the proposed strategies, which have been shown to relate to adherence (Aelterman et al. 2013; Wang, Lin, and Huang 2012). Moreover, a balanced distribution of the different preventive strategies was observed and suggests a high adherence towards the provided strategies. In the future, this intervention might be considered for implementation in PETE programmes or in CPD programmes for in-service PETs.

Notes

1. A bachelor's degree of PE in Belgium is granted by colleges and universities and requires minimum three years of study. A Master's degree of PE can be obtained after having the bachelor's degree and requires another one or two (since 2013) years of study in Belgium.

2. Percentages display the ratio of the implementation of one preventive strategy in relation to the overall use of preventive strategies.

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CHAPTER 3 || *EFFECTS OF A MULTIFACTORIAL INJURY PREVENTION INTERVENTION IN PHYSICAL EDUCATION TEACHERS: A RANDOMIZED CONTROLLED TRIAL*

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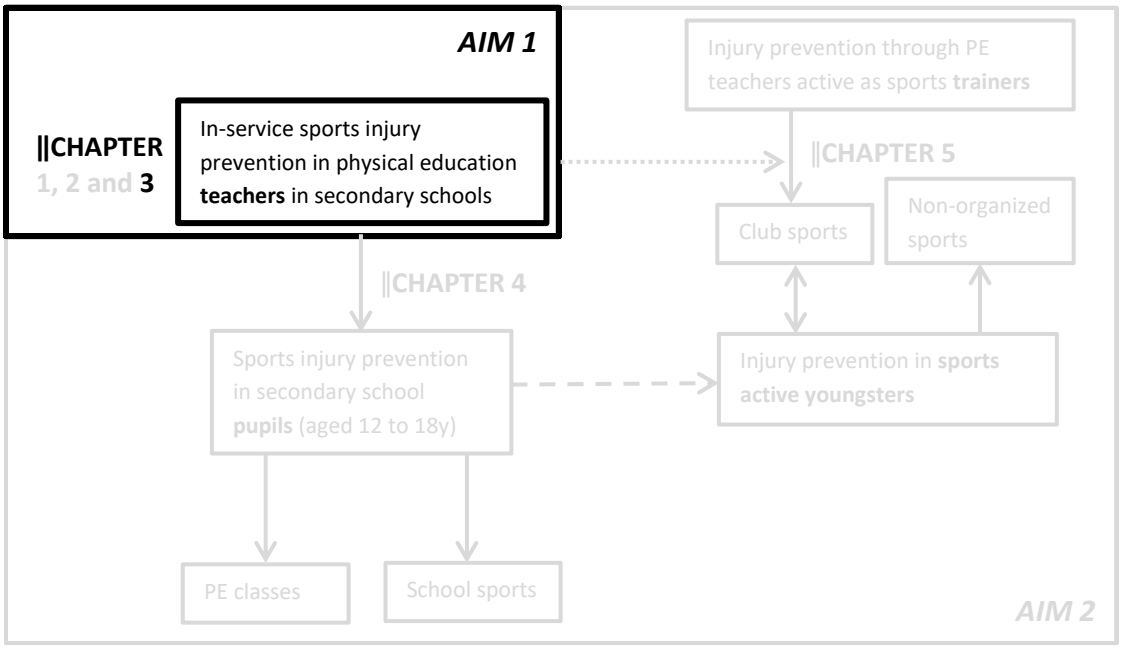
AIM 1
‖CHAPTER 1, 2 and 3
In-service sports injury prevention in physical education **teachers** in secondary schools
‖CHAPTER 4
Sports injury prevention in secondary school **pupils** (aged 12 to 18y)
PE classes
School sports
Injury prevention through PE teachers active as sports **trainers**
‖CHAPTER 5
Club sports
Non-organized sports
Injury prevention in **sports active youngsters**
AIM 2

ABSTRACT

Physical education (PE) teachers are at a high risk of musculoskeletal sports or work-related injuries because of the physical activity as inherent part of their profession. Such injuries have a negative impact on work and leisure time activities, and effective injury prevention interventions are needed. The present study aimed at testing the effectiveness of an injury prevention intervention that was developed and optimized according to PE teachers' wishes and values. Fifty-five PE teachers were randomly assigned to intervention or control group. Intervention group teachers engaged in two days of training during which they familiarized with eight injury prevention strategies (seven intrinsic and one extrinsic). A special feature of the intervention was that the way of delivery was based on the self-determination theory in order to stimulate participants' motivation to adhere to the proposed strategies. Prospective registrations during one school year were conducted concerning injuries and preventive behaviours. Results showed that the intervention group teachers had a lower number of injuries per 1000 h time of exposure (TOE) than the controls (INT: 0.49, CON: 1.14 injuries/1000 h TOE, OR: 2.32, 95% CI: 1.06–5.07), and applied a broader variety of strategies including dynamic and static stretching, core stability, balance and strength training, when compared to the controls who mainly engaged in warming-up. In conclusion, with the same amount of time, an injury reduction was found in PE teachers through a more balanced use of provided preventive strategies.

Background

Many physical education (PE) teachers combine PE teaching in schools with the provision of extra-curricular sporting activities. At the same time, they may actively participate in sports themselves (Lemoyne, Laurencelle, Lirette, & Trudeau, 2007; Sandmark, Wiktorin, Hogstedt, Klenell-Hatschek, & Vingard, 1999). This commitment to physically demanding activities puts them at a higher risk for sustaining musculoskeletal injuries when compared to most other occupations, such as non-PE teachers (Goossens, Vercruysse, et al., 2015). Several studies showed that PE teachers have to deal with a substantial amount of musculoskeletal injuries (Goossens, Vercruysse, et al., 2015; Kovac, Leskosek, Hadzic, & Jurak, 2013; Lemoyne et al., 2007; Pihl, Matsin, & Jurimae,

2002; Sandmark, 2000). These musculoskeletal injuries in PE teachers induce work-related consequences as well as personal consequences such as a reduced participation in leisure time activities. For example, the lower back injuries in PE teachers (Goossens, Vercruysse, et al., 2015; Kovac et al., 2013; Pihl et al., 2002) are often cited (Deyo & Weinstein, 2001) as a major cause of disability (e.g. prolonged absence from work; Lemoyne et al., 2007) and inability to work (e.g. the inability to assist pupils). These observations warrant a need for injury prevention in this population.

To design effective interventions that reduce injuries in PE teachers, one can rely on a substantial body of research generated from interventions developed for and evaluated in sporting contexts (Leppänen, Aaltonen, Parkkari, Heinonen, & Kujala, 2014). This research revealed that the adaptation of one single prevention strategy cannot effectively prevent injury, but on the other hand multifactorial interventions, consisting of different prevention strategies are needed.

A distinction is usually made between effective intrinsic (Amako, Oda, Masuoka, Yokoi, & Campisi, 2003; Arnason, Andersen, Holme, Engebretsen, & Bahr, 2008; Cumps, Verhagen, & Meeusen, 2007; Emery & Meeuwisse, 2010; Malliou, Rokka, Beneka, Mavridis, & Godolias, 2007; Scase, Cook, Makdissi, Gabbe, & Shuck, 2006) and extrinsic prevention strategies (Lambson, Barnhill, & Higging, 1996; McKay, Goldie, Payne, & Oakes, 2001; Milgrom, Finestone, Ekenman, Simkin, & Nyska, 2001). Intrinsic strategies refer to measures that can be adopted by the users themselves (e.g. improving core stability, flexibility), while extrinsic strategies refer to altering aspects of the users' environment, generally considered beyond the control of the users (e.g. providing a better floor in the gym). Only the choice of appropriate footwear forms an effective extrinsic prevention strategy which is within the control of the users (Lambson et al., 1996; McKay et al., 2001).

Although one can draw from the existing literature to determine the contents of intervention schemes, one major challenge in terms of the interventions' effectiveness is related to the users' adherence to the proposed scheme (Myklebust et al., 2003; Verhagen, Hupperets, Finch, & Van Mechelen, 2011; Verhagen, Voogt, Bruinsma, & Finch, 2014). It has been postulated that injury prevention can be addressed as a

behavioural trait, and implementation of preventive measures requires behavioural change strategies (Verhagen, Van Stralen, & Van Mechelen, 2010). One empirically validated theory that can help to optimize preventive behaviour and implement preventive evidence is the self-determination theory (SDT) (Chan & Hagger, 2012; Deci & Ryan, 2000). SDT suggests that individuals will be more optimally, this is autonomously, motivated to change their behaviour when their three basic psychological needs are fulfilled, that is, autonomy, competence and relatedness (Deci & Ryan, 2000). They are then more likely to either enjoy or understand the value of the proposed behavioural change (Chan & Hagger, 2012). Previous studies indeed suggested that, to increase an intervention's effectiveness and promote autonomous motivation towards long-term engagement in the proposed strategies, it is important to consider the way the intervention is delivered and whether the approach taken by the trainer is nurturing the users' needs for autonomy, competence and relatedness (e.g. Aelterman et al., 2013). Teachers' need for autonomy (i.e. a sense of volition and psychological freedom when engaging in an activity; Deci & Ryan, 2000) can be nurtured by providing choices in exercises. To support teachers' need for relatedness (i.e. the experience of closeness, trust or friendship in relationships with others; Baumeister & Leary, 1995), the continuing professional development provider can allow interaction, and try to create a positive atmosphere among the participants. To support teachers' need for competence (i.e. feelings of success and effectiveness; White, 1959), it is crucial to provide attainable exercises.

Considering the need for effective interventions targeting sports- or work-related injury prevention in PE teachers, and the existing knowledge on effective prevention strategies, including the supportive evidence on delivery methods that focus on nurturing the users' three basic needs, a multifactorial intervention was developed and optimized that is SDT-driven and concurs well with PE teachers' wishes and values (Vercruysse, De Clercq, Goossens, Aelterman, & Haerens, 2015). The goal of the current study was to assess the effects of this multifactorial intervention on the occurrence of sports- or work-related injuries and preventive behaviours in PE teachers, through a randomized-controlled trial (RCT) design.

Methods

Population and procedure

One hundred and five secondary schools in Flanders (Belgium) were contacted to participate in the study. For schools that showed an interest, a follow-up e-mail with more information about the study was sent to the school's PE teachers who could choose to enrol in the study. A total of 104 teachers from 62 schools enrolled, and were randomly assigned to the intervention or control group via the function ASELECT in Microsoft Excel 2010. Teachers from the same school were treated as one unit in the randomization procedure to avoid possible contamination between teachers. After randomization, only 92 PE teachers from 56 schools provided written informed consent and started the study.

Throughout the study 26 of the 92 teachers (28%) dropped out due to a hectic daily schedule (n = 9), the inability to be present at a training part (n = 6), not teaching PE classes this school year (n = 1), obstruction by the school board (n = 3) and personal reasons (n = 7). Besides, 11 teachers (12%) were eliminated from the final analyses due to inadequate registrations (less than 30 weekly registrations and no retrospective questionnaire). This resulted in a final population of 55 PE teachers from 39 different schools, of whom 29 out of 19 schools participated in the intervention group (7 men, 22 women; mean age: 46.5 ± 10.0), and 26 PE teachers out of 20 different schools were part of the control group (15 men, 11 women; mean age: 48.7 ± 8.5). The final set of 55 PE teachers completed a first set of baseline questions at the start of the school year in September 2013. In addition, teachers received a weekly reminder e-mail including a link to an online injury and preventive behaviour survey. These weekly registrations started the third week of September and ended in the last week of June, resulting in a total of 42 registered weeks. PE teachers who registered less than 30 times were asked to complete a retrospective survey concerning the missing values.

The protocol of the study was approved by the Ethics Committee of the Ghent University Hospital (protocol number EC/2013/160).

Intervention

The intervention has been described in detail elsewhere (Vercruysse et al., 2015) and was based on the injury prevention intervention tested in PE Teacher Education students by Goossens, Cardon, Witvrouw, Steyaert, and De Clercq (2015). The intervention in the present study was delivered exclusively to the intervention group on two separate days, one in September and one in December. Day one included a part with theoretical background and rationale of each intrinsic preventive strategy (1 h 15 min) and a practical part with exercises concerning neutral spine position, core stability and functional strength training (1 h 45 min). Day 2 consisted of three practical parts; warming-up with dynamic stretching (30 min), exercises implementable in daily life (e.g. brushing your teeth on one leg; 1 h 30 min) and cooling down with static stretching (30 min). The intervention aimed at training and stimulating teachers to engage more frequently in a wider range of intrinsic prevention strategies which can be changed by the teacher itself (e.g. increasing muscle strength). During the two training days, teachers received training schedules and didactical posters illustrating the exercises, so that it would be easier to re-engage in the exercises at work or at home. The training days were furthermore complemented with five bi-monthly reminders, that were sent by e-mail and were also posted on a secured Facebook page, and teachers had access to a website where they could consult all the information and could watch instructional videos with all of the exercises (Figure 1). The control group did not receive any intervention, nor any information concerning the prevention strategies.

The content of the intervention included seven intrinsic strategies; correct performance, warm up (a general cardiovascular part followed by a specific warm up, including dynamic stretching exercises), cooling down, stretching (dynamic stretching at the beginning and static stretching at the end or independently of a sports activity), core stability, balance and functional strength) and one extrinsic (appropriate footwear) prevention strategy. The intervention was delivered according to principles of SDT (Ryan & Deci, 2000) in order to improve teachers' adherence to the proposed prevention strategies. For example, at the beginning of the training the trainer allowed time for teachers to get to know each other (need for relatedness), and he/she listened carefully to their wishes and needs in order to be able to adapt the training accordingly. Teachers'

competence was nurtured by providing a wide range of exercises, each with three difficulty levels, and teachers themselves could choose which exercises and level they preferred (need for autonomy).

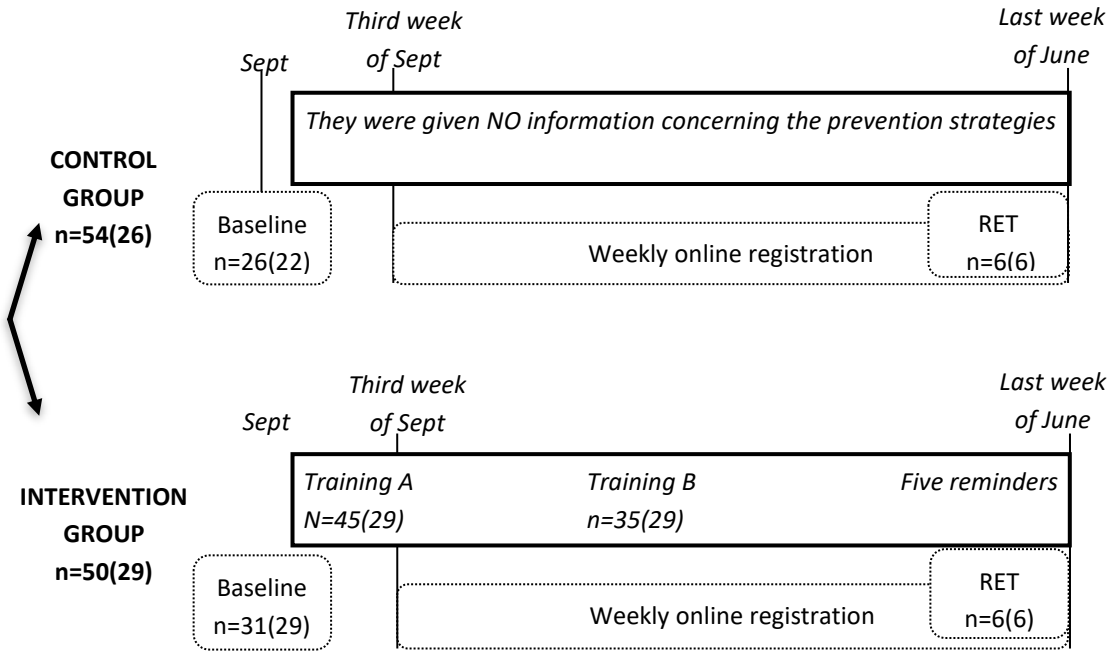

Figure 1. Design of the study over time with indications of the different parts of the intervention (Training A, Training B, Bimonthly reminders) and moments of registration. Number of participants per part or questionnaire is given, with number after drop-out between brackets. RET=retrospective questionnaire

Outcome measures

Group demographics. Prior to the start of the study, all teachers answered questions concerning demographics (age, gender), their history of teaching PE (hours per school year), sports history (number of years, months and hours per sport) and engagement as a trainer in a sports club (yes or no). In addition, they also indicated their injury history of the previous 6 months. These questions were based on the baseline questionnaire of Goossens, Verrelst, Cardon, and De Clercq (2013).

Number of injuries per 1000 hours of exposure and preventive behaviour. The present study was aimed to assess the effects of the intervention on the number of sports- or work-related injuries per 1000 h time of exposure (TOE), and on teachers' preventive

behaviours. Both outcomes were assessed through a weekly registration in an online tool.

A musculoskeletal sports- or work-related injury was defined as any injury sustained during periods of teaching PE, being active as a trainer, or practicing sports, with one or more of the following consequences: the teacher had to stop the activity and/or was suffering from pain during sports participation or teaching and/or was not able to (fully) participate in the next planned PE class, training session or sports activity. This definition was based on the recommendation made by the Council of Europe (Van Mechelen et al., 1996). The main researcher (S.V.) and two co-authors (D.D.C. and L.G.) objectively judged every registered case of injury, until they all had the same opinion, without knowledge of the corresponding group (intervention or control). Furthermore, in this study, an acute injury was defined as a musculoskeletal injury that suddenly occurred, whereas for a chronic injury teachers experienced already pain or discomfort in that specific body part before. Contact injuries are caused by the contact with another person or sports equipment other than the playing surface, while this is not the case with non-contact injuries. A first-time injury is an injury the teacher never had before, whereas a recurrent injury is the recurrence of the exact same injury a teacher ever had in the past.

Teachers indicated weekly if a sports- or workrelated injury occurred in the past week and, if so, they provided more details concerning the injury definition, injury localization, injury type, injury characteristics (acute/chronic, contact/non-contact, first-time/recurrent), TOE on the day they became injured and circumstances of the inciting event (injury occurred during sport participation, being active as a trainer or PE teacher, or has gradually developed). Because the intervention is designed to prevent the teachers from first-time as well as recurrent injuries, in all analyses not only first injuries but all sports- or work-related injuries occurring during the intervention period were taken into account. Besides injury registration, also TOE was reported weekly and included the hours of teaching PE, being active as a trainer and engaging privately in sports.

To measure time spent in preventive behaviours, all teachers weekly registered the time they spent daily on any of the prevention strategies (warm up, cooling down, core stability, balance, functional strength, static and dynamic stretching).

Analysis

To compare variables at intake in both conditions, Pearson $\chi 2$ tests were applied for the dichotomous variables and a two-tailed t-test was applied for the exposure time variables and age.

A statistical comparison of the number of sports- or work-related injuries per 1000 h TOE between the intervention and control groups was done by means of a Wald test assuming a Poisson distribution. Means and Wald 95% confidence intervals (CIs) were calculated using the SPSS EM Means procedure. The same test was used for the subdivision of the injuries by characteristics and circumstances. Gender and randomization at school level were included as covariates.

An independent samples T-test was conducted to compare time spent on prevention strategies between groups. The same test was done for the number of times they applied a prevention strategy per week. All statistical analyses were done in SPSS 21 (IBM SPSS Statistics for Windows, Version 21.0. Armonk, NY: IBM Corp.).

Results

Preliminary analyses

No significant baseline differences between the intervention and control groups were found (see Table I), except that the intervention group contained more female teachers when compared to the control group ($\chi 2 = 6.431$, $P = .011$).

Table I. Demographics of participants

Characteristics	Control group (n=26)	Intervention group (n=29)
Injured in 6 months prior to the study, n (%)	12 (46)	15 (51)
Being active as a trainer in sports club, n (%)	6 (23)	7 (24)
History as a PET, mean (±SD) (hours/school year)	17826 (7721)	19213 (10264)
Sports history, mean (±SD) (hours of sport played in the past)	8601 (6737)	11985 (13842)
Recreational (±SD) (% of total sports history)	29.0 (31.4)	27.4 (26.2)
Competitive (±SD) (% of total sports history)	68.2 (35.3)	72.6 (26.2)
Age, mean (±SD) (year)	47.6 (8.9)	47.4 (9.9)
Gender, n (%)**		
Men	15 (58)	7 (24)
Women	11 (42)	22 (76)
Time of exposure during the present school year, mean (±SD) (min/w)	675 (265)	744 (263)

**p<0.05

Effects on number of injuries per 1000 exposure hours

Nineteen of the 26 registered musculoskeletal injuries in the control group and 11 of the 17 registered musculoskeletal injuries in the intervention group were in line with the definition of a sports- or work-related injury. Eleven of the 26 teachers in control and 7 of the 29 teachers in the intervention group suffered from one or more injuries. The number of injuries per 1000 h TOE was significantly (P = .035) lower in the intervention group than in the control group (INT: 0.49, CON: 1.14 injuries/1000 h TOE, OR: 2.32, 95% CI: 1.062–5.068).

Effects on injury characteristics and circumstances

Table II. Number of sports or work related injuries subdivided by characteristics and circumstances, corresponding TOE (time of exposure) and number of injuries per 1000h time of exposure.

	Control group			Intervention group		
	Number of sports- or work related injuries	TOE (h)	Number of injuries per 1000 exposure hours (95% CI)	Number of sports- or work related injuries	TOE (h)	Number of injuries per 1000 exposure hours (95% CI)
Characteristics						
Acute	10	17538	0.62 (0.33 to 1.16)	6	21576	0.26 (0.12 to 0.59)
Chronic	9		0.52 (0.25 to 1.05)	5		0.23 (0.10 to0.56)
Contact	4		0.23 (0.08 to 0.64)	7		0.31 (0.14 to0.67)
Non-contact	15		0.91 (0.54 to 1.55)**	4		0.18 (0.07 to 0.48)**
First-time	10		0.64 (0.34 to 1.18)	6		0.23 (0.10 to 0.54)
Recurrent	9		0.51 (0.18 to 0.93)	5		0.24 (0.10 to 0.58)
Circumstances						
Sport participation	8	4461	1.75 (0.83 to 3.66)	7	6168	0.88 (0.41 to 1.90)
Teaching/coaching	7	13077	0.54 (0.24 to 1.18)	3	15408	0.20 (0.06 to 0.61)
Gradually developed	4	17538	0.25 (0.09 to 0.68)	1	21576	0.042 (0.01 to 0.31)

**p<0.05

Table II provides an overview of the number of injuries per 1000 h TOE subdivided according to the characteristics of the injuries, namely acute/chronic, contact/non-contact and first-time/recurrent. It also shows the circumstances at the moment the injury occurred in terms of whether teachers were engaging in sporting activities, were coaching or teaching or whether the injury gradually developed throughout different activities. Only for non-contact injuries, the intervention group had a significantly (P = .005) lower number of injuries per 1000 h TOE than the control group (INT: 0.18, CON: 0.91 injuries/ 1000 h TOE, OR: 5.147, 95% CI: 1.64–16.13). The non-contact injuries are situated predominantly in the lower limbs in both groups. Moreover, no significant differences in the TOE (being active as teacher, as trainer or practicing sport) on the day

of injury were found between the intervention (mean = 2.01 ± 1.87 h) and control (mean = 2.13 ± 2.11; P = .879) groups.

Preventive behaviour

The intervention group (46.4 min/week SD = 25.9 vs. 36.4 min/week SD = 36.7) did not significantly differ from the control group (P = .254) in the mean time spent in preventive behaviours. However, results showed a greater variety of strategies being applied in the intervention group with teachers in the intervention group engaging significantly more in strength (INT = 0.9 times a week; CON = 0.3), balance (INT = 1.1; CON = 0.1), core stability (INT = 1.2; CON = 0.3) and dynamic stretching (INT = 1.1; CON= 0.6) when compared to the control group. Teachers in the control group engaged significantly more in warm-up activities (INT = 1.5; CON= 2.5) when compared to teachers in the intervention group (Figure 2).

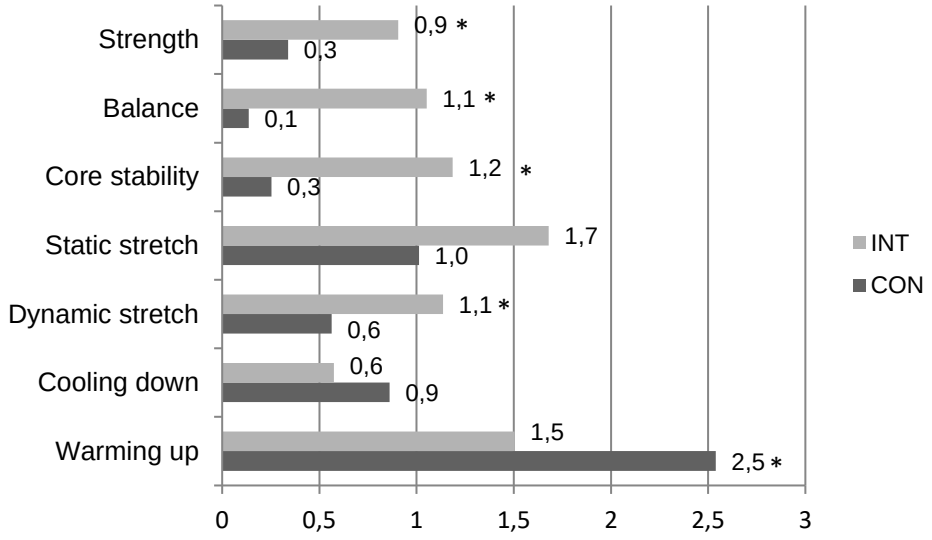

Figure 2. Overview of the times each preventive strategy was applied weekly in control (CON) and intervention group (INT)
*p<0.05

Discussion

Due to the high level of physical activity as part of their occupation (Sandmark et al., 1999), PE teachers sustain a high number of musculoskeletal injuries (Kovac et al., 2013; Lemoyne et al., 2007; Pihl et al., 2002), which have a negative impact on work and leisure time activities (Lemoyne et al., 2007). As such the present study aimed at testing the effectiveness of a multifactorial intervention targeting injury prevention on the number of sports- or workrelated injuries per 1000 h TOE and preventive behaviour. Given that the intervention was designed for teachers themselves, and considerable evidence exists on the effectiveness of intrinsic prevention strategies in different sport populations (Longo et al., 2012; Olsen, Myklebust, Engebretsen, Holme, & Bahr, 2005; Soligard et al., 2008), the intervention aimed at training and stimulating teachers to engage more frequently in a wider range of intrinsic prevention strategies which can be changed by the teacher itself (e.g. more muscle strength).

The multifactorial intervention including eight different preventions strategies, that was delivered in a way that supports the teacher's needs for autonomy, competence and relatedness, generated two positive results. First of all, a significantly lower number of injuries per 1000 h TOE was found in the intervention group compared to the control group. Secondly, teachers of the intervention group applied a wider range of intrinsic injury prevention strategies. We discuss each in turn.

The intervention resulted in a significantly lower number of injuries per 1000 h TOE in the intervention group compared to the control group. According to the injury characteristics, a significantly lower number of injuries per 1000 h TOE of non-contact injuries was obtained in the intervention group compared to the control group. An explanation could be that in our study, the focus was on providing several intrinsic prevention strategies (e.g. technique, balance, strengthening and stretching exercises), which are already proven to reduce mainly non-contact injuries (e.g. non-contact leg injuries; Bennell, 2008). In order to also reduce contact injuries, more extrinsic prevention strategies (e.g. adapting floor conditions, game rules, material, etc.) should have been provided. We have deliberately not provided those extrinsic prevention strategies, as this depends more on the school and policy makers instead of the teachers

themselves. The characteristics of the non-contact injuries were divided by location (mostly lower limbs), injury type (strain, tear, inflammation) and inciting event (diverse sports- or work-related reasons) but the small number of injuries did not allow in depth analysis of these non-contact injury characteristics between the intervention and control groups.

The RCT design was supplemented by a comparison of potentially influencing personal factors at intake between the teachers in the intervention and control groups. Neither age, nor injury prevalence in the 6 months previous to the study, nor PE teaching or sports history differed, which reinforced that the overall lower number of injuries per 1000 h TOE in the intervention group may indeed be attributed to the preventive effect of the intervention. The one potentially influencing personal factor that differed in both groups was the proportion of men and women in each group. The proportion of women was higher in the intervention group compared to the control group (which was due to randomization at school level). Some previous studies showed female teachers to sustain more musculoskeletal disorders than male teachers (Chiu & Lam, 2007; review of Erick & Smith, 2011). If this would apply to the population tested in the current study, a difference in injury prevalence, retrospectively reported over a period of 6 months before intake, would be apparent. As this injury prevalence at intake did not significantly differ for men and women in both conditions, the effect of the intervention can be considered as an overall group effect that was not influenced by a different proportion between sexes in the control and intervention groups. Moreover, to take this baseline difference into account, gender was added as a covariate in the analyses and as the results showed an overall significantly lower number of injuries per 1000 h TOE in the intervention group compared to the control group, it can be assumed that the different proportion of gender in the intervention and control groups had no influence on the outcome of the intervention.

The explanation of the lower amount of injuries in the intervention group may be found in the diversity of strategies applied through the programme. Teachers who participated in the intervention group did not spend more time on prevention strategies altogether (INT = 46.4 min/week; CON= 36.4 min/ week), but their time was distributed across a wider range of strategies. This is a positive finding, as previous intervention studies

(Coppack, Etherington, & Wills, 2011; Fortington et al., 2014; Longo et al., 2012; Olsen et al., 2005) already suggested that it is not the duration but the content of the intervention and correct performance of the proposed exercises that is crucial to decrease the number of injuries. While the intervention group engaged in strategies such as strength, balance, core stability, or static and dynamic stretching, the control group predominantly engaged in warm-up activities. Indeed, a good warm up has long been considered as one of the most important injury prevention strategies (Malliou et al., 2007; Soligard et al., 2008), and throughout their teacher education programme PE teachers are extensively trained to design and engage in good warm-up activities. However, Leppänen et al. (2014) concluded that more variation in prevention interventions should be provided and that stretching, muscle strengthening, proprioceptive training, etc. requires an equal amount of attention. Clearly, this information is new to many PE teachers, and the intervention succeeded in stimulating a more balanced use of prevention strategies, whereas the controls only focused on warm up.

Strengths and limitations

A limitation of the present study is the relatively high attrition bias (i.e. selection bias caused by loss of participants), as from the initially 104 enrolled PE teachers, 92 started the intervention but only 55 completed the minimum number of registrations. A second limitation is the unintended higher amount of women in the intervention group compared to the control group, which was tried to neutralize by including gender as covariate in the analysis. A further subdivision of the results by gender was not made, while these subgroups would become too small to make reliable comparisons. Strengths of this study are the highly accurate registration of TOE, the weekly injury registrations, and weekly implementation of the prevention strategies. First, a correct proportion of the occurred injuries in 1000 h of TOE could be compared between both groups, and our data could be compared to that from other studies that also used TOE to indicate the number of injuries (Michaelidis & Koumantakis, 2014). Second, the adherence to the proposed prevention strategies is measured in terms of minutes and proportions. Third, intervention studies were already conducted in various sport specific young populations (Longo et al., 2012; Olsen et al., 2005; Soligard et al., 2008), but rarely intrinsic

prevention strategies were tested in adults participating in multiple sports (military recruits: Coppack et al., 2011). The positive results of the present study are of therefore of great value for injury prevention in populations that engage in multiple sports.

Perspective

Our multifactorial intervention targeting injury prevention significantly reduced the number of injuries per 1000 h TOE in PE teachers and resulted in a more balanced use of the different strategies. The intervention can now be disseminated on a larger scale and there is also scope to test variations of the intervention in other occupations or other groups that engage in multi-sport activities (e.g. bachelor PE teacher education students). Further, in future studies it might be interesting to test whether PE teachers transfer their knowledge and the provided intervention materials, such as the didactical posters, towards the students when teaching PE in school.

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Disclosure statement

No potential conflict of interest was reported by the authors.

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CHAPTER 4 || *EFFECTIVELY TRAINING PHYSICAL EDUCATION TEACHERS TO IMPLEMENT INJURY PREVENTIVE STRATEGIES INTO THEIR PE LESSONS*

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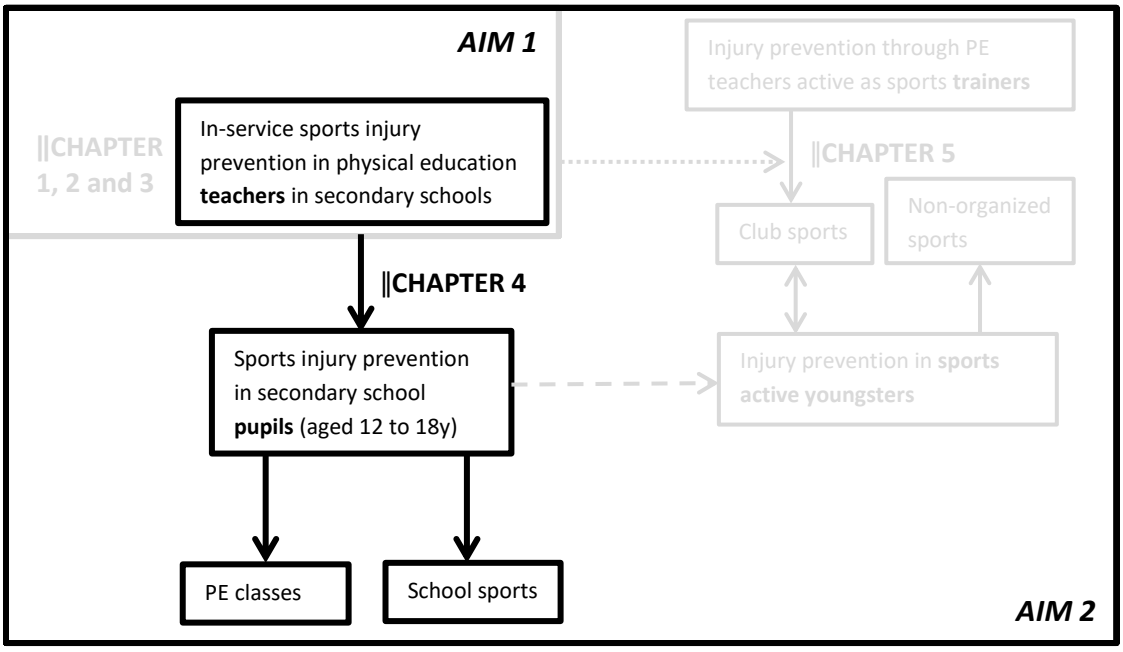
(Submitted on 02-09-2016)


AIM 1
Injury prevention through PE teachers active as sports **trainers**
‖CHAPTER 1, 2 and 3
In-service sports injury prevention in physical education **teachers** in secondary schools
‖CHAPTER 5
Club sports
Non-organized sports
‖CHAPTER 4
Sports injury prevention in secondary school **pupils** (aged 12 to 18y)
Injury prevention in **sports active youngsters**
PE classes
School sports
AIM 2

ABSTRACT

Previous studies showed that physical education teachers (PETs) can be effectively trained to implement injury preventive strategies into their own lives. However, to decrease negative effects of sports injuries in adolescents, injury prevention within this population is also needed. Therefore, a randomized controlled trial in fourteen PETs was conducted to train PETs to implement injury preventive strategies both in their own lives and in their PE lessons. Per PET one of their classes of pupils (n=271) from second grade was questioned as well. The first aim in this study was to investigate whether an intervention can effectively improve PETs' injury preventive knowledge. The second aim was to investigate whether participation in the intervention led to more implementation of the prevention strategies in PETs own extra-curricular sporting activities. Thirdly, and most central to the current study, we wanted to investigate whether the PETs' implementation of injury preventive strategies in their PE lessons enhanced after receiving the intervention. The injury preventive intervention resulted in an improvement of PETs' injury preventive knowledge ($F(10,2)=7.718$, $p=0.005$), PETs' preventive behaviour in own extra-curricular sporting activities ($F(14,2)=4.105$; $p=0.047$) and in their teaching behaviour towards the pupils in PE lessons ($F(14, 2)=3.147$; $p=0.061$). Reports of pupils pointed in the same direction as the reports of PETs. In conclusion, the injury preventive intervention improved PETs injury preventive knowledge, enlarged the implementation of injury prevention in their own extra-curricular sporting activities and most central to the current study, effectively affected PETs teaching behavior during PE lessons.

Introduction

It is well known that physical activity or sports participation at a moderate intensity enhances physical and mental health (Janssen and LeBlanc, 2010). However, activity levels in children and adolescents decreased considerably over the last decades (Brettschneider, Frankfurt, and Naul, 2015), causing negative effects on young people's health and considerable economic costs (Trasande and Elbe, 2012). Within a sport-active population, sports injury is one of the main reasons to cause demotivation towards sports (Kelm et al., 2001) and to quit sports (Crane and Temple, 2015). Rexen et al.

(2015) showed that injuries in schoolchildren reduce the development in physical fitness by 17-18 percent. This way, sports injuries imply an important general health burden (Kull, 2002) with even economic consequences (Kelm et al., 2001). Other draw backs of sports injuries in children and adolescents are absence from school and associated educational failure (Barnes et al., 2001). Considering the fact that seventy % of all acute injuries in the Flemish youth (6-18years) is due to sports activities (Cumps and Meeusen, 2006), the negative impact of sports injuries to Flemish children and adolescents is important. So, in order to decrease this negative impact, sports injury prevention should receive sufficient attention in competitive and recreational sports-activities, as well as in physical education (PE).

Many injury preventive strategies have proved to effectively reduce injuries in various sports populations (e.g. LaBella et al., 2011; Bizzini and Dvorak., 2015; Malliou et al., 2007). Moreover, it has been demonstrated that multifactorial injury preventive interventions, focussing on more than one prevention strategy, can lower the occurrence of musculoskeletal injuries in both sport-specific and multisport populations (Leppänen et al., 2014; Parkkari, Kujala, and Kannus 2001; Vercruysse et al., 2016b).

Nevertheless, throughout different intervention studies, the lack of adherence to the proposed strategies has been noted as a crucial problem (Myklebust et al., 2003; Verhagen et al., 2011). Because self-determination theory (SDT) states that autonomous motivation is an important determinant of adherence to health-related behavior (Deci and Ryan, 2000), it seems crucial to foster autonomous motivation for applying the strategies when designing an intervention. Autonomous motivation and adherence to the proposed strategies can be increased if teachers' psychological needs for autonomy, competence and relatedness are fulfilled. Indeed, previous studies showed that interventions that are implemented in a need supportive way are well appreciated by the PETs (Aelterman et al., 2013; Vercruysse et al., 2016a).

Emery, Hagel, and Morrongiello (2006) state that for child sport injury prevention, only limited responsibility should be put on the child itself (e.g. doing warming up at the beginning of a sports activity). Instead, the parents (e.g. providing adapted sports shoes), but mainly the coach of the child (e.g. implementing preventive strategies in PE

lessons) carry important responsibility. Furthermore, also sports organizations (e.g. providing better sports materials) and governments (e.g. introducing new game rules) are to a high extent responsible for child sport injury prevention.

Next to the sports context, PE lessons are a powerful environment to reach sports active adolescents in terms of injury prevention. Since PE lessons are compulsory in primary and secondary school in Flanders, all children and adolescents, independent from whether they participate in organized and non-organized sports, can be reached through the PE teacher (PET). Outside the context of the PE lessons, PETs are also the driving forces in school sports activities, offering another context for injury prevention application. Several studies tried to reduce sports injuries through PE or school sports and confirm that introducing injury prevention through PE is possible (Collard et al., 2010; Emery et al., 2007).

Although PETE programs prepare to teach injury preventive strategies in pupils, the PETs themselves also suffer from musculoskeletal injuries. High injury prevalence rates in PETs have been reported (Kovač et al., 2013; Lemoyne et al., 2007; Pihl, Matsin, and Jurimae, 2002) and injury risks are higher than non-PETs (Goossens et al., 2015). These high prevalence rates are caused by the physical workload (Sandmark et al., 1999) in combination with an extensive sports history and current sports participation (as coach or athlete; Lemoyne et al., 2007). Injuries not only affect teachers' personal activities (e.g. being unable to go running in their spare time), but may also cause a direct effect on pupils as professional obstructions occur (e.g. being absent from work). For these reasons, injury prevention is also needed in PETs. The big advantage to make an intervention both focused on injury prevention in pupils and PETs, is that PETs are used to function as a sportive reference model. If PETs themselves apply correct injury preventive behaviors (e.g. correctly lifting materials), pupils might adopt those behaviors more easily.

With all the above in mind, a transfer directed injury preventive intervention was developed based on previous work. In a previous study, an intervention containing eight prevention strategies was proven to be effective for reducing sports injury incidences in PETE (Goossens et al., 2015). In a next study, in order to reduce injuries in the PETs'

population, the existing injury preventive intervention (Goossens et al., 2015) was further optimized according to PETs' needs and wishes (Vercruysse et al., 2016a). Afterwards, this optimized intervention was tested on larger scale in the PETs population, which showed that participation in the intervention resulted in a reduction of sports- or work related musculoskeletal injuries (Vercruysse et al., 2016b). The content of the optimized intervention is described in Vercruysse et al. (2016a; 2016b). The delivery of the intervention was based on SDT to stimulate the autonomous motivation for the application of injury preventive strategies. An integrated approach, where an injury preventive intervention not only aims at enhancing the PET's intentions to apply the strategies themselves, but also stimulates PETs to include them in their PE lessons is now timely.

As knowledge is suggested to positively affect adherence (Wang, Lin, and Huang, 2012), the first aim in this study is investigating whether the transfer directed injury preventive intervention can successfully improve PETs' knowledge, regarding epidemiology (in PETs and pupils) and the proposed preventive strategies. The second aim is investigating whether it is possible to obtain increases in the implementation of preventive strategies in PETs own extra-curricular sporting activities after receiving the intervention. Thirdly, the study aimed at investigating whether the intervention successfully enhances PETs' implementation of injury preventive strategies in their PE lessons.

Methods

Population & procedure

A convenience sample of fourteen PETs of seven different secondary schools in Flanders (Belgium), who were all presently active as a PET in the second grade (14-16years), voluntarily participated in the study and provided written informed consent. The volunteers were randomly assigned to intervention (5 women and 2 men; Mage 41.43±10.21) or control group (3 women and 4 men; Mage 38.86 ± 8.32) via the function ASELECT in Microsoft Excel 2010. PETs from the same school were treated as one unit in the randomization to avoid possible contamination between colleagues. PETs in intervention group had on average 16.86(±11.39) years of teaching experience, 4(55%)

of them had obtained a bachelor's degree in PE and 3(45%) achieved their master's degree. The controls had on average 13.64(±8.24) years of teaching experience, 3(45%) of them had obtained a bachelor's degree in PE and 4(55%) achieved their master's degree. There was no drop-out in this study.

Per PET one of their classes of pupils from second grade was questioned (INT: 139 pupils, 48.2% girls); CON: 132 pupils, 56.8% girls). The intervention classes were taught 73.4% in academic and 35.6% in technical education. Control classes were taught 53% in academic, 35.6% in technical and 11.4% in vocational education.

All questionnaires (see *Instrumentation*), except for the baseline questionnaire, in PETs and adolescents were assessed three times; pre (week before the intervention), post (4 weeks after receiving the intervention) and follow-up (7 weeks after receiving the intervention). Table 1 provides an overview of the research questions, coupled with the associated measurements and their timing, and the statistical test.

The ethical committee of the Ghent University Hospital approved the protocol of the study (protocol number EC/2013/160).

Table 1. A structured overview of the study.

Research question	Design: measurement and timing	Statistics
(1) PETs' injury preventive knowledge		
Can we improve the injury preventive knowledge, regarding epidemiology (in PETs and pupils) and the proposed preventive strategies, by means of the intervention?	PETs: Pre (week before the intervention), post (four weeks after receiving the intervention) and follow-up (seven weeks after receiving the intervention) questionnaires were completed in intervention and control group regarding knowledge of epidemiology and the proposed preventive strategies	3 X 2 Repeated measures ANOVA using SPSS
(2) PETs' extra-curricular preventive behaviour		
Do PETs more frequently implement injury preventive strategies in extra-curricular sporting activities after participating in the intervention?	PETs: Pre, post and follow-up questionnaires were completed in intervention and control group regarding their preventive behaviour in extra-curricular sporting activities	3 x 2 Repeated measures ANOVA in SPSS
(3) PETs' injury preventive teaching behaviour		
Do PETs more frequently implement injury preventive strategies in PE lessons after participating in the intervention?	PETs: Pre, post an follow-up questionnaires were completed in intervention and control group regarding their preventive teaching behavior Pupils: Pre, post and follow-up questionnaires were completed, assessing the preventive behaviour of their PET in PE lessons	3 X 2 Repeated measures ANOVA using SPSS Multilevel repeated measures analyses using MLwiN

Intervention

PETs of the intervention group received an expanded version of an existing injury preventive intervention (Vercruysse et al., 2016a) that proved to be effective in reducing PETs' injuries (Vercruysse et al., 2016b). The intervention consists of a theoretical part (3h) and practical part (3.5h) in which eight preventive strategies (correct performance, warm up, cooling down, stretching, core stability, balance, functional strength training and appropriate footwear) are covered. For the present study, the content of each part was expanded by not only emphasizing the application of the strategies by PETs themselves (Vercruysse et al., 2016a; 2016b), but also addressing how teachers can include the strategies in their PE lessons. To illustrate, PETs participated in a memory game with functional strength exercises; and small ball races where a good core stability

is needed (e.g. as fast as possible passing a ball to the pupils of your team in push up position); as well as in interactive exercises performed in pairs. Supplementary examples on how preventive strategies could be integrated in sport-specific lessons (e.g. standing on one leg, while trying to pull a handball out of the hands of the other) were also provided. PETs also received didactical posters that could be used by their pupils during PE. Moreover, when compared to earlier studies (Vercruysse et al., 2016a; 2016b), the number of didactical posters was expanded to obtain more variation and a wider range of exercises. Suggestions of repetitions and sets of exercises were adapted to pupils' level, and on the back side of the didactical poster a figure indicating the active muscle(s) during that specific exercise was added (example see https://figshare.com/articles/Examples_of_didactical_posters/3438761). Besides suggestions provided by the researcher, PETs had the opportunity during the training to figure out how they would implement the preventive strategies in PE lessons and how to make it topic-related. To do so, a brainstorm session was added where PETs could share ideas on how to implement the strategies in PE. In accordance with previous studies (Vercruysse et al., 2016a; 2016b), an SDT-based delivery approach was used to motivate PETs to implement strategies both in their own lives as in their PE lessons.

Instrumentation

At baseline, a small questionnaire regarding gender, age (birthdate), teaching experience (amount of years and months) and diploma (bachelor/master) was administered in PETs to compare some demographics in intervention and control group. Gender, school year (first/second school year in second grade) and educational level (academic/technical/vocational) was questioned within the pupils.

PETs' injury preventive knowledge (Aim 1) was assessed by means of an existing online questionnaire (Vercruysse et al., 2016a), containing 13 multiple-choice questions relating to the different preventive strategies (e.g. Which may be related to low back pain? These questions had multiple choice options that only had one correct answer: a) Only too strong abdominal muscles compared to back muscles b) Only too weak abdominal muscles compared to back muscles c) Both too strong and too weak abdominal muscles compared to back muscles d) I don't know) and the epidemiology of

injuries (e.g. About 70% of all acute injuries in the Flemish youth (6-18 years) is caused by sports. a) This statement is correct b) This statement is false c) I don't know).

PETs' extra-curricular preventive behavior (Aim 2) was registered online, questioning the amount of minutes they practiced per preventive strategy, the kind of sport they practiced and the amount of hours doing so. This existing online tool was used in a previous study (Vercruysse et al., 2016b).

PETs' injury preventive teaching behaviour (Aim 3) was assessed through a similar online registration measuring the amount of minutes per strategy teachers implemented in PE lessons. The questionnaire for the pupils, concerning preventive strategies taught by the PET, was conducted on a iPad. This allowed an easier data collection and stimulated pupils to fill out the questionnaire. Seven questions regarding the different preventive strategies were assessed per PE lesson (e.g. How frequently do you do a dynamic stretch at the beginning of the PE lesson (these are exercises where you stretch your muscles while you are moving (e.g. swinging your leg forward repeatedly) and scored on a five-point Likert scale (0=inapplicable, 1=never, 2=in less than 50% of the PE lessons, 3=in 50% of the PE lessons, 4=in more than 50% of the PE lessons, 5=always). The question regarding balance was accidentally removed from the questionnaire. Correct performance and attention for adapted footwear was questioned in a yes-no formulation. This questionnaire was based on the previous questionnaire in teachers (Vercruysse et al., 2016b), adapted to pupils level and tested in a class of pupils in the last year of primary school. All possible confusions were indicated by those pupils and eliminated so that clarity in the questions was guaranteed. In order to eliminate social desirability bias, the study was blinded for the pupils.

Data analysis

Pearson χ^2 tests were applied to compare dichotomous variables at intake in PETs and pupils to compare intervention and control group. Moreover, a two-tailed t-test was applied for age and teaching experience in PETs.

The statistical comparisons of the evolution in knowledge between intervention and control group over time was done by means of a 3 (pre, post, follow-up) x 2

(intervention and control group) repeated measures ANOVA. The same test was used for the comparison of the use of preventive strategies in PETs' own sporting activities and for PETs' injur preventive teaching behavior. Wilks' Lambda is reported for the multivariate tests and Sphericity was Assumed in univariate tests.

As pupils were nested within classes, multilevel repeated measures analyses were conducted to compare changes in pupils' perceptions of their PETs' injury preventive teaching behavior in intervention and control group. Multilevel analyses allow to take into account the nested structure of the pupil data and three-level models (time, pupil, class) were used as they fitted better than the four-level models (including school level as well).

All statistical analyses in PETs were done in SPSS 21 (IBM SPSS Statistics for Windows, Version 21.0. Armonk, NY: IBM Corp.) and for analysis in pupils MLwiN 2.31 (Rasbash et al., 2014) was used.

Results

Group demographics

At baseline no significant differences were found in age (intervention group (INT): 41.4±10.2 years; control group (CON): 38.±8.3; p=0.615), teaching experience (INT: 16.9±11.4 years; CON: 13.6±8.2; p=0.557), gender (INT: 28.6% men; CON: 57.1%; χ2=1.167, p=0.280) and diploma (INT: 42.9% bachelors; CON: 57.1%; χ2=2.86, p=0.593) of PETs in intervention group compared to controls. In pupils, no significant difference was found in gender (INT: 51.8% men; CON: 43.2%; χ2=2.015, p=0.156), but were found in school year (INT: 54.7% in second school year; CON: 71.2%; χ2=7,918, p=0.005) and educational level (INT: 73.4% academic, 26.6% technical, 0% vocational; CON: 53.0%, 35.6%, 11.4%; χ2=21.978, p<0.001). Therefore, in analysis of the pupils, the latter two variables were added as covariates.

PETs' injury preventive knowledge (Aim 1)

A significant time by group interaction effect was found for teachers' knowledge (F(10,2)=7.718, p=0.005). Inspection of the within group time effects showed that

teachers in the intervention group significantly improved in knowledge over time (INT: F(5,2)=17.394; p=0.022) with scores significantly improving from pre (3.7/10) to post (6.5/10; p=0.006) and from pre to follow-up (6.9/10; p=0.020), whereas no significant changes (CON: F(5,2)=0.244; p=0.798) were found in the evolution of knowledge in the control group (pre: 3.5/10, post: 4.0/10, follow-up: 3.8/10).

PETs' extra-curricular preventive behavior (Aim 2)

An overall significant time by group interaction effect was found for the different preventive strategies applied by PETs in own extra-curricular sports activities (F(14,2)=4.105; p=0.047). Hereby teachers in intervention group showed a trend towards a significantly increased application of the different preventive strategies after receiving the intervention, whereas this remained the same in controls (CON: F(7,2)=1.019; p=0.426; INT: F(7,2)=4.229, p=0.084). Figure 1 illustrates the sum score of the minutes dedicated per preventive strategy during one training hour.

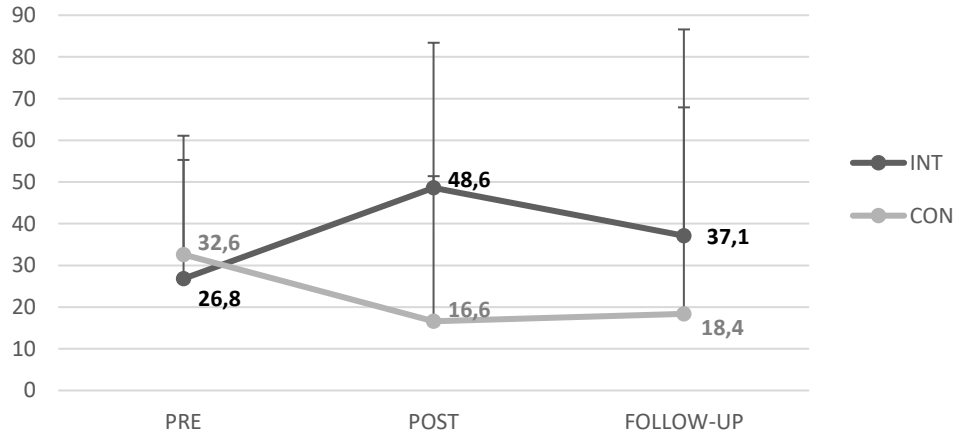


Figure 1. Mean amount of minutes per extra-curricular sporting activity (60min) PETs applied preventive strategies, reported by the PETs themselves, on three moments (pre, post, follow-up) intervention (INT) and control (CON) group.

PETs from the intervention group applied significantly more warming up, cooling down, dynamic and static stretch, core stability, balance and strength training from pre to post, compared to the controls. Also significant improvements in intervention group, compared to the controls were found in dynamic stretching, core stability and balance training from pre to follow-up. Significant decreases in intervention group were found

for warming up and static stretch from post to follow-up. More details about the evolutions per preventive strategies can be found in appendix 1.

PETs' injury preventive teaching behavior (Aim 3)

An overall trend towards a significant time by group interaction effect was found for the application of the different preventive strategies in PE lessons as reported by PETs ($F(14,2)=3.147$; $p=0.061$). Hereby teachers in intervention group reported an increased implementation of the different preventive strategies, whereas this remained the same in control group (CON: $F(7,2)=0.401$; $p=0.678$; INT: $F(7,2)=5.280$, $p=0.023$). Figure 2 shows the sum score of the minutes dedicated per preventive strategy during one PE lesson of 50 minutes. As some preventive strategies can be applied in combination (e.g. correct landing technique while doing balance exercises), the sum score can transcend the total duration of a PE lesson (50 minutes).

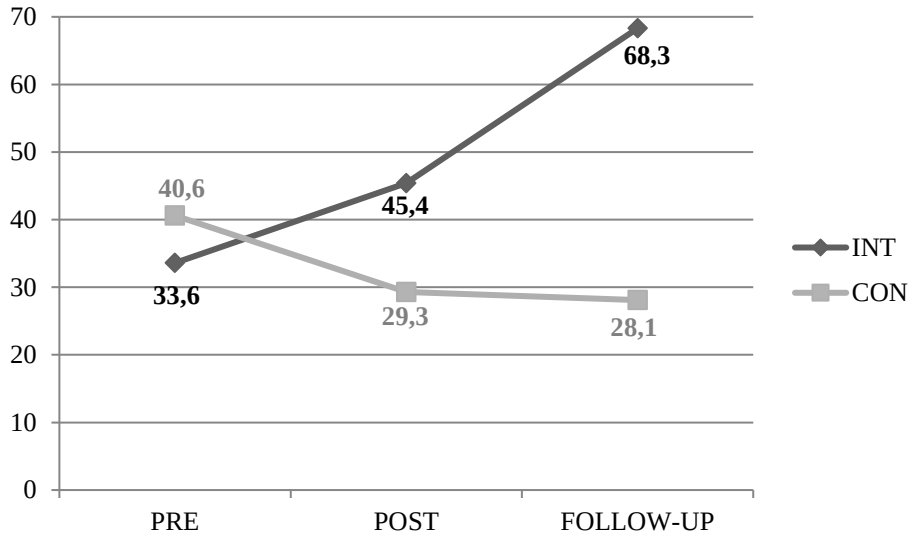


Figure 2. Mean amount of minutes per PE lesson (50min) PETs implemented preventive strategies, reported by the PETs themselves, on three moments (pre, post, follow-up) in intervention (INT) and control (CON) group.

Significant improvements from pre to follow-up for warming up, and from pre to follow-up and post to follow-up for dynamic stretching, were found in intervention group, compared to the controls. A decrease in static stretch was seen in both groups from pre to follow-up, but was significant higher in control compared to intervention group. More details about the evolutions per preventive strategies can be found in appendix 2.

Some significant changes in the application of preventive strategies were also reported by the pupils. Warming-up slightly increased from pre to follow-up in the intervention group, while this decreased in the control group. Functional strength training in upper and lower limbs increased from pre to post in the intervention group, whereas this decreased a little in the controls. Functional strength training in upper limbs also improved from pre to follow-up in the intervention group, while this remained the same in the controls. Static stretching improved in the control group, while this remained the same in the intervention group from pre to follow-up (see table 2).

Table 2. Mean score for the implementation of preventive strategies in PE lessons by the PET, as reported by the pupils on a scale of 0 to 5. Scores are given for intervention (INT) and control (CON) group, with interaction-effects between time and group.

		INT			CON			Interaction effect		
		PRE	POST	FU	PRE	POST	FU	PRE-POST	POST-FU	PRE-FU
CP		0.37	0.41	0.40	0.58	0.68	0.60			
WU		2.7	2.9	2.8	3.1	2.8	2.4			***
CD		2.1	2.3	2.4	1.9	2.0	2.4			
DS		3.3	3.5	3.3	1.8	1.7	2.0			
SS		2.3	2.4	2.3	1.8	1.5	2.1			**
CORE		2.9	3.2	2.8	2.0	2.0	2.0			
BAL		1.8	1.3	0.5	1.3	1.4	1.0			
STR	*UL*	2.9	3.3	3.1	2.1	1.9	2.0	***		**
	LL	2.8	3.3	2.9	2.5	2.0	1.9	**		

CP=correct performance, WU=warming up, CD=cooling down, DS=dynamic stretch, SS=static stretch, CORE=core stability, BAL=balance, STR=strength, UL=upper limbs, LL=lower limbs
$p^{**}<.05$, $^{***}p<.01$

Discussion

Drop out in sports (Crane and Temple, 2015) and decreased activity levels in adolescents (Brettschneider, Frankfurt, and Naul, 2015) are partly due to sport injuries. To minimize injury incidences and benefit the positive effects of physical activities in adolescents (Janssen and LeBlanc, 2010) a transfer directed injury preventive intervention for PETs was developed. The PE setting was chosen because all adolescents can be reached and injury prevention fits in the attainment goals of PE at school. On top of that, PETs benefit from participating in an injury preventive program as they frequently suffer from sports

injuries themselves (Goossens et al., 2015) and a multifactorial injury preventive intervention can reduce these injuries within this population (Vercruysse et al., 2016b).

The transfer directed injury preventive intervention was delivered towards PETs and resulted in improvements of PETs' injury preventive knowledge, PET's preventive behavior in own extra-curricular sporting activities and teaching behavior towards the pupils in PE lessons.

First of all, improvements of knowledge over time, concerning epidemiology of sports injuries in both PETs and pupils and of the proposed preventive strategies, were seen in the intervention group compared to the controls. These results strengthen previous preliminary findings in a pilot study in PETs (Vercruysse et al., 2016a) and predict a positive effect on the adherence of the intervention (Wang, Lin, and Huang, 2012).

The second aim was to obtain more implementation of preventive strategies in PETs own extra-curricular sporting activities. In a previous study (Vercruysse et al., 2016b) was found that PETs did not increase in the amount of time implementing the provided strategies after receiving the intervention. Results of the current study, were more convincing as the transfer directed intervention successfully stimulated teachers to apply all the preventive strategies more into their extra-curricular sporting activities. A first possible explanation for the differences between both studies is that in the current study, the principles of SDT were used even more to autonomously motivate the PETs. The attractive and entertaining exercises and teaching methods may have stimulated the PETs to implement them in their own training. Secondly, as PETs have to transfer injury preventive knowledge and behavior to the pupils, they have the possibility to act as role model for the pupils and might more quickly perform "the good behavior" as well (Keats et al., 2012). Lastly, PETs may have used the preventive strategies more as they may have wanted to figure out how and when they can implement the strategies in their PE lessons, by exploring it in their own trainings.

In a previous study (Vercruysse et al., 2016b) was already shown that teachers who received the intervention applied a greater variety of strategies. In line with these findings, the current study showed that PETs applied the preventive strategies in a more

balanced way. While most teachers are used to include warming-up, some static stretching and correct performance, other preventive strategies such as cooling down, dynamic stretch, core stability, balance training and strength exercises are less commonly used. Therefore it is important that the intervention resulted in improvements of all but one preventive strategies from pre to post. The one preventive strategy that did not change from pre to post is applying correct performance, as this was used already very frequently at pre level. However it is assumed here that correct performance could improve a lot in quality. During the intervention teachers were trained how to correctly give feedback to each other on exercises with lots of concerns to cause injuries (e.g. correct landing technique after a jump).

The third aim in this study concerns transfer of injury prevention from PET towards pupils. An enhancement in PETs' implementation of injury preventive strategies in PE lessons was set as a goal. When teachers participated in the intervention, they applied the intervention strategies more often into their PE lessons. The total implementation of strategies increased, whereas differences were found only in warming up, dynamic and static stretching. Slightly increases in correct performance, cooling down, core stability, balance and strength training seem to appear, but should be encouraged more in further research. Although warming up was used a lot at pre level already, it was applied more after receiving the intervention. Teachers were informed in the theoretical part of the intervention that a warming up should last at least 10 minutes. An increase from 6.9min at initial level to 11.7min/PE lesson was observed in the intervention group, which follows the guideline. Furthermore, dynamic stretching was recommended in combination with a warming up to fit in the definition of a warming up (Smith, 1994). Static stretching instead was recommended in combination with cooling down. Attention was paid to this guidelines as not only warming up improved in the intervention group, but also the implementation of dynamic stretching. Static stretching was performed more at initial level and showed a small decrease, most probably due to the fact that static stretching was part of warming up instead of cooling down before receiving the intervention. However, the provided guidelines of at least 5 minutes (10-15min is even better) are yet reached (CD: 2.9min and SS 3.7min) and within the context of PE it is unlikely to enlarge this even more due to time constrains.

Lastly, pupils' perception of their teachers' preventive teaching behavior resulted in a small increase in the use of warming up in intervention group, while a decrease was seen in control group. This strengthens the self-reports of the teachers. Secondly, a different evolution was found in the results of static stretching from pre to follow-up where implementation in the intervention group remained the same, but implementation in the control group increased. This is in contrast with the teachers' assessments, where static stretch in both groups decreased. Furthermore, pupils reported to have seen more implementation of strength exercises for both upper and lower limbs. This is also in line with the registrations of the teachers, where an increase was seen over time, although not significantly (CON: 0.9-3.4-0.0; INT: 2.3-4.0-3.4min/PE lesson). Even though only a few changes were observed, they seem largely in line with the assessments in PETs themselves.

Strengths and limitations

The strength of the study consists of reaching two key target populations at once in terms of injury prevention. The strong content, based on eight prevention strategies, and the motivating way of delivery, based on SDT allow for an easy and effective implementation in both populations. A limitation in this study is the difference in way of registering PETs' preventive behavior in the self-reports filled out by teachers (min/PE lesson) and pupils (Likert-scale from 0-5), making it hard to compare the findings of both informants. Secondly, only a small number of PETs took part in this study, although despite of this limitation, still some major significant differences were found.

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Note:

The transfer of injury prevention in the pupils towards their own extra-curricular sporting activities was assessed through a pre (before the intervention; January 2015), post (four weeks later; February 2015) and follow-up (three weeks later; March 2015) questionnaires in pupils in chapter 4. But as this part of the questionnaire (which was also measuring PE teachers preventive behaviour in PE lessons) came at last, pupils lost attention and mostly filled out randomly answers (such as always indicating the fourth answer) or skipped big parts (e.g. indicating they did not participate in school sports, although they did, in order to get rid of the questionnaire more quickly, as they could then skip the questions concerning injury prevention in school sports). The reliability of this section is therefore highly questionable and was not added. However, the first part of this questionnaire, concerning PE teachers' preventive behavior, was completed very accurately. This because pupils were still focused and felt some external control of their PE teachers who were also present in the room.

CHAPTER 5 || *IMPLEMENTATION OF A MULTIFACTORIAL SPORTS INJURY PREVENTION IN AND THROUGH PE TEACHERS: A RANDOMIZED CONTROLLED TRIAL*

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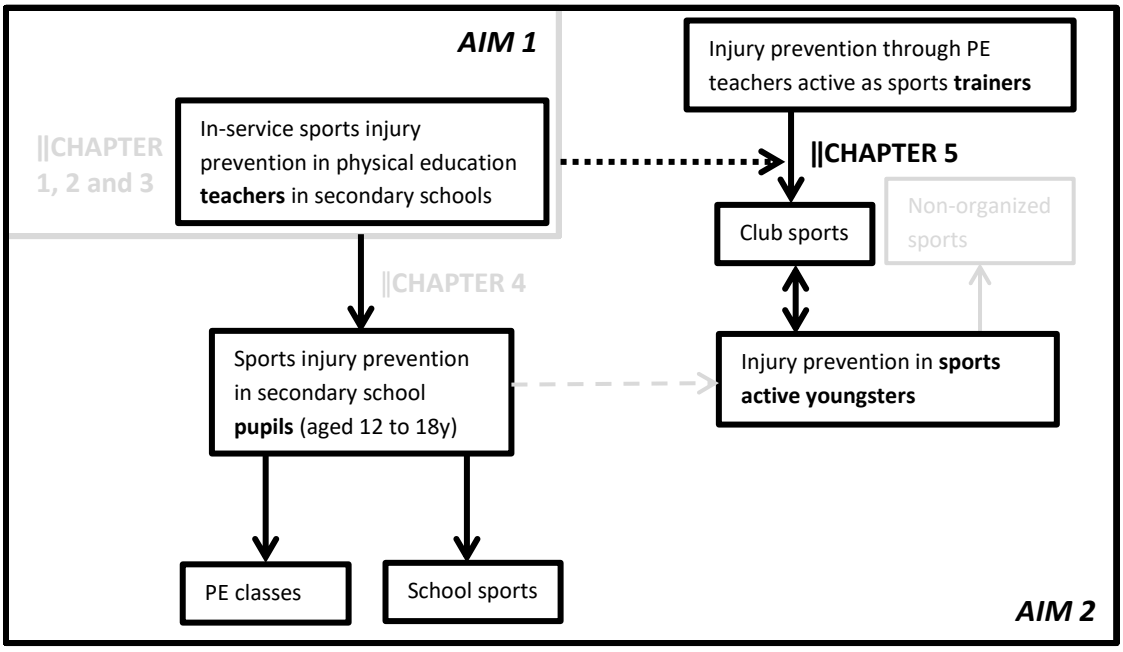
AIM 1
Injury prevention through PE teachers active as sports **trainers**
‖CHAPTER 1, 2 and 3
In-service sports injury prevention in physical education **teachers** in secondary schools
‖CHAPTER 5
Club sports
Non-organized sports
‖CHAPTER 4
Sports injury prevention in secondary school **pupils** (aged 12 to 18y)
Injury prevention in **sports active youngsters**
PE classes
School sports
AIM 2

ABSTRACT

Positive evolutions in adolescents' sports participation are beneficial for health, but at the same time an augmented report of injuries is documented. The many related negative effects of injuries in adolescents call for effective injury prevention intervention for adolescents. Introducing an injury prevention intervention through PE teachers (whether or not active as trainer) enables to reach all adolescents (whether or not active in a sports club). In the current study, a randomized controlled trial was set up to investigate the potential of an existing multifactorial injury prevention intervention (i.e. No Gain With Pain; Goossens et al., 2015a) for promoting injury prevention among adolescents through PE teachers. Results revealed that after receiving the intervention, PE teachers' injury preventive knowledge increased. Secondly, positive changes were found in perceived utility and implementation of the preventive behaviors in two of the three investigated contexts, that is during teachers' own sport participation and when they were teaching physical education. No changes for perceived utility were found for the third context, that is the training context, but also in this context positive changes in the implementation of the preventive behaviors were noticed. So, the intervention successfully increased implementation of injury prevention strategies in contexts where many adolescents are active.

Introduction

A positive evolution in Flemish adolescents' participation in sports has been documented recently, with 81.8% of the adolescents participating in sports in 2009 (Scheerder et al., 2013), and 83.7% engaging in sports in 2014 (Scheerder et al., 2015). Such figures are encouraging given the well-known health benefits associated with physical activity and sports participation (Hallal et al., 2006). At the same time, researchers have documented that adolescents often experience injuries when engaging in sport, with variations from 1.30 to 8.14 injuries/1000h of exposure to sports (Beachy and Rauch, 2014; Malisoux et al., 2013; Theisen et al., 2013; Vanderlei et al. 2014). Injuries cause not only drop-out in sports (Indridadottir et al., 2015; Crane & Temple, 2015) with related negative effects on the general health, but may also cause absence from school with possible educational failure, which is often paired with less social

contact with classmates. Heavy economic costs for medical treatment and forced parental work absence were also reported. Finally, when adolescents are injured, this often causes transport issues for the parents (Hallal et al., 2006; Barnes et al., 2001; Sörensen et al., 1998). Effective injury prevention in adolescents is thus needed to foster sustained participation in sports and to avoid many physical and mental health issues, as well as economic and social consequences.

Many effective injury prevention interventions are known in adolescents (e.g. LaBella et al., 2011; McHugh et al., 2007), but most of them are sport specific (e.g. handball: Olsen et al., 2005; soccer: Arnason et al., 2008), many apply only one preventive strategy (e.g. static stretching: Amako et al., 2003) and some of them focus only on one particular body part (e.g. low back pain: Durall et al., 2009; ankle sprains: McHugh et al., 2007). However, it is shown that multifactorial injury prevention programs have the greatest impact on reducing injuries in sport-specific populations (Leppänen et al., 2014; Parkkari et al., 2001) as well as multisport groups (Goossens et al., 2015a). The latter authors (Goossens et al., 2015a) applied a multifactorial injury prevention intervention that is based on different preventive strategies. The intervention named “No Gain With Pain” (NGWP), initially developed for physical education teacher education students (Goossens et al., 2015a), relies on seven intrinsic (correct landing and cutting performance, warm up, cooling down, stretching, core stability training, balance training, and functional strength training) and one extrinsic (appropriate footwear) preventive strategy. The intervention was tested and proved to be effective to prevent injuries in PETE students (Goossens et al., 2015a) and physical education (PE) teachers (Vercruysse et al., 2016b), suggesting that multifactorial interventions incorporating the eight preventive strategies of NGWP could be effective in other multisport populations as well.

However, not only the content of interventions has to be chosen in a well-considered way, but also the delivery approach is of utmost importance to have the greatest possible adherence towards the provided preventive strategies (Myklebust et al., 2003; Verhagen et al., 2011). According to self-determination theory (SDT; Deci and Ryan, 2000) it is crucial to stimulate autonomous motivation towards injury prevention through the delivery approach (Chan and Hagger, 2012). This can be realized by

nurturing the three psychological needs for autonomy (e.g. adolescents can choose themselves which preventive exercises they can perform), competence (e.g. adolescents experience some forms of success while doing the preventive exercises) and relatedness (e.g. adolescents have confidence and trust in the trainer of the intervention).

Injury prevention for adolescents can take place in several contexts where they are active (e.g. in sports club or at school). Because in Flanders, Belgium, compulsory PE counts from the year a child turns 6 years till the year the adolescent turns 18 years, we chose to target the school context. That way, also youngsters participating in non-organized sports could be reached. Implementation of injury prevention in PE lessons in secondary schools also contributes to the final attainment goals of PE, in which injury prevention is a component. Moreover, because PE teachers are well qualified (bachelor/master degree) and have potential (e.g. didactical skills) to transfer knowledge and behavior regarding injury prevention towards their pupils, the context of PE seems to be ideal. Many PE teachers fulfill the role of sports trainer in a sports club (Kovac et al., 2011). Thus, PE teachers have the ability to provide injury prevention to all adolescents during PE lessons and - when being active as a sports trainer - to adolescents engaged in club sports.

In our previous research, the effectiveness of NGWP for reducing injuries in PE teachers (Vercruysse et al., 2016b) could be related to high appreciation of the intervention and high perceived utility of the provided strategies by PE teachers (Vercruysse et al., 2016a). These high appreciation scores could be related to the high injury risk PE teachers experience themselves (Goossens et al., 2015b), and the approach taken during the intervention (SDT-based). Because PE teachers understand the value of injury prevention they are well-placed to teach injury prevention to adolescents. In a previous study, we already effectively trained PE teachers to apply the strategies into PE lessons (Vercruysse et al., in revision).

Apart from replicating the findings of previous studies (Vercruysse et al., in revision), we investigate in the current study whether, by further developing the NGWP intervention, that is by incorporating more sports oriented components, it would be possible to also effectively stimulate PE teachers – also active as a sports trainer - to implement the

preventive strategies in organized sport activities in a sports club. If this would be possible, we can conclude that NGWP is effective in training PE teachers to implement the strategies when being active themselves (Vercruysse et al., 2016b), to integrate the strategies into PE lessons (Vercruysse et al., in revision), as well as into sports club activities (current study). Four aims were formulated for the current study. Aim 1 was to confirm that the adapted NGWP resulted in a positive evolution of PETs' injury preventive knowledge, as knowledge is assumed to positively affect adherence (Wang et al., 2012). Secondly, we wanted to explore the change of PETs' perceived utility and implementation of the strategies for their own sport participation. Aim 3 was investigating whether changes in perceived utility and implementation of the preventive strategies in PE lessons towards the students are present. The last aim was to investigate whether participation in the intervention of PE teachers who are also active as a sport trainer results in increases in perceived utility of the strategies for sport club activities and higher implementation of the strategies in organized sport club activities.

Method

Participants

Three hundred principals of secondary schools in West-Flanders (Belgium) were contacted by phone to be informed of the study. If interest was shown, a follow-up e-mail was sent to recruit the PE teachers of the schools who could choose to enroll in the study. Seventy four PE teachers, of which thirty eight were also active as a trainer in a sports club, signed up to voluntarily participate. They were randomly assigned to either intervention or control group via the function ASELECT in Microsoft Excel 2010. Random allocation was not conducted by the researchers involved in the current study. When conducting randomization teachers from the same school were clustered as one unit to avoid possible contamination between teachers. Those teachers who were also active as a sports trainer (n=38) were also randomly divided across both groups. After randomization, twenty four teachers out of fourteen different schools started the registrations in the control group (Mage: 44.9±12.1 years, 8 female, 10 active as trainer) and twenty five teachers out of sixteen different schools were actually participating in the intervention group (Mage: 45.2±9.7 years, 8 female, 12 active as trainer).

Procedure

At pre-test, all enrolled teachers filled out a questionnaire (pre) concerning the knowledge about and utility of the provided injury preventive strategies. Knowledge of the epidemiology in both PETs and adolescents and of the preventive strategies was assessed. Utility of the strategies was assessed in relation to three contexts a) when they were active themselves, b) in their PE lessons and c) for their coaching activities in the sport club. Six weeks later (post) this questionnaire was assessed a second time when teachers in the intervention group had engaged in the one-day intervention (in week three or four), and then again six weeks later a last time (follow-up).

Teachers' engagement in preventive behavior in the same three contexts was assessed weekly. Every Monday, during 12 weeks, teachers received a reminder e-mail including a link to an online preventive behavior survey.

The protocol of the study was approved by the Ethics Committee of the Ghent University Hospital (EC/2016/0813).

Intervention

For the current study, we adapted a previously developed intervention program (Goossens et al., 2015a). The intervention is more fully described elsewhere (Vercruysse et al., 2016a). In short, the content of the intervention exists of eight injury preventive strategies (correct performance, warm up, cooling down, stretching, core stability, balance, functional strength and appropriate footwear) which were explained in a theoretical part (2h15), could be discussed during a brainstorm session (45min) and could be experienced during a practical (3h) part. The delivery approach was based on SDT (Ryan & Deci, 2000) in order to not only autonomously motivate PE teachers in their own preventive behavior, but also on how to autonomously motivate adolescents towards injury preventive behavior in both PE lessons and in trainings. Therefore, new in the present intervention, was the brainstorm session, where PE teachers could discuss and be creative about implementing SDT in their PE lessons and trainings. Stimulation of the implementation of the preventive strategies at training level was realized by providing a folder containing 136 didactical posters presenting exercises on the different

strategies (example see https://figshare.com/articles/Examples_of_didactical_posters/3438761). Interactive teaching methods and organizational changes were offered to show how the basic exercises could be made more sport specific. Additionally, to obtain interaction and stimulate them to share ideas and good practices a secured Facebook page was launched. Only the intervention group received the one-day intervention, whereas controls did not receive any program, nor any information concerning the strategies. However, the controls received the intervention after the study was finished.

Measurement instruments

Teachers first filled out a registration form which questioned their name, school, activity as a trainer in a sports club, e-mail, phone number and birth date.

Similar to a previous study (Vercruysse et al., 2016a), injury preventive knowledge was assessed with 12 items (e.g. Which may be related to low back pain? These questions had multiple choice options that only had one correct answer: a) Only too strong abdominal muscles compared to back muscles b) Only too weak abdominal muscles compared to back muscles c) Both too strong and too weak abdominal muscles compared to back muscles d) I don't know.) In the results, a converted score on 10 is provided.

Perceived utility was measured with eight items, one for each of the eight preventive strategies (e.g. Performing static stretching at the end of a sports activity is:), which had to be scored on a five-point Likert scale from 1 (totally useless) to 5 (totally useful). Intra-rater reliability of these sets of questions was tested in 18 PETE students and all outcomes scored average to excellent (all ICCs>0.40) according to the Fleiss reliability scale (Fleiss 1986). The questionnaire was filled out three times, with reference to their own participation in physical activity and sport, with reference to the PE lessons, and with reference to the context of the sport club.

Similar to a previous study (Vercruysse et al., 2016b), teachers' engagement in preventive behavior was questioned weekly. The amount of hours teaching PE, education year, amount of minutes used per preventive strategy per PE lesson, and the

subjects of the PE lessons were assessed. The latter was assessed to check whether the subjects of the PE lessons (organized by category: Category A=fitness and athletics, B=rhythmic/dance movements, C=gymnastics, D=ball sports and E=other) in both groups did not differ. Also, registrations about their sports activities in the past week (which sport, amount of hours at what level) and implemented strategies (minutes in total of the past week) were done. Lastly, if teachers were also active as a trainer in the previous week, they filled out the amount of hours they were providing training and the minutes used per preventive strategy per 60min. Preventive behavior was measured every week, with means scores of weeks three and four consisting the pre-test, mean score of weeks seven and eight comprising the post-test, and mean score of weeks 11 and 12 being the follow-up measures. In weeks two, nine and 10 teachers and students had holidays and in week five and six the intervention was provided.

Data analysis and statistical analysis

At baseline, a Pearson $\chi 2$-test was conducted to compare gender and an independent samples t-test was used to compare age in the intervention and control group. As the adaptation of the NGWP program dealt with incorporating sports specific elements, the subjects of the PE lessons were organized according to categories. Differences between control and intervention group were inspected with a Pearson $\chi 2$-test. Differences in teaching and training (being active as a trainer and train themselves) hours, and pre scores of the different outcomes (knowledge, preventive behavior and perceived utility) were analyzed with independent samples t-tests.

Repeated measures ANOVA with measurement as within subject variable and condition (intervention/control) as between subject variable, were used to compare pre, post and follow-up measurements in the control and the intervention group. A P-value of <0.05 was considered as statistically significant and $0.1>P>0.05$ was considered as a trend towards significance. All analyses were done in SPSS21 (IBM SPSS Statistics for Windows, Version 21.0. Armonk, NY: IBM Corp.).

Results

Analyses at baseline

There were no significant differences between control and intervention group for age (t=-0.084; p=0.934) and gender (χ2=0.012; p=0.912). Subjects of PE lessons did not significantly differ at pre (χ2=7.049; p=0.133), post (χ2=2.249; p=0.690) or follow-up (χ2=6.163; p=0.187) between control and intervention group. At pre-test, none of the outcomes was significantly different between control and intervention group, except for applying the preventive strategy "correct performance" in PE lessons (CON: 6.7±5.9; INT: 3.2±3.1min/PE lesson; F=5.991, p=0.031) and for perceived utility of static stretching in trainings towards athletes (CON: 2.8±1.0; INT: 3.9±1.0). A baseline difference was found for the amount of hours PE teachers were doing sports themselves (CON: mean score of 4.4h; INT: mean score of 12.2h; F=2.674; p=0.029). Therefore, the amount of hours doing sports at pre level was included as covariate when analyzing effects on preventive behavior in extra-curricular sporting activities. No significant differences in teaching (CON: mean score of 13.4h/week; INT: mean score of 14.4h; F=2.196, p=0.631) or training (giving training: CON: 6.05±9.9; INT: 9.4±15.4h; t=-0.846; p=0.403) hours were found.

Preventive knowledge

A significant time by group interaction effect was found for PE teachers knowledge (F(44,2)=14.197; p<0.001). Whilst control scores remained the same, teachers from the intervention group improved from pre to post, and from pre to follow-up, but decreased scores were found from post to follow-up (CON: 5.2-4.5-4.9; INT: 4.2-7.0-5.8 on 10).

Own extra-curricular sporting activities

An overall time by group interaction effect was found for perceived utility in own sporting activities and pre to follow-up scores also positively increased. Positive changes were found for correct performance, warm up, dynamic stretch, static stretch, balance and strength in lower limbs (table 1).

Table 1. Perceived utility of the provided strategies in own extracurricular sporting activities (OWN), expressed as a mean score on a maximum score of 5, in both control and intervention group over time.

	Control group			Intervention group			Interaction effect			
	Mean score (± SD)			Mean score (± SD)			F-value			
	pre	post	follow-up	pre	post	follow-up	pre-post-follow-up	pre-post	post-follow-up	pre-follow-up
OWN	3.7 (0.6)	3.7 (0.6)	3.8 (0.6)	3.8 (0.8)	4.1 (0.6)	4.2 (0.7)	1.829*	0.868	1.390	2.612**
correct performance	4.4 (1.0)	4.2 (0.9)	4.0 (1.2)	4.2 (0.9)	4.5 (0.6)	4.5 (0.9)	1.367	1.082	0.287	2.947*
warm up	4.8 (0.4)	4.6 (0.5)	4.6 (0.5)	4.7 (0.9)	4.8 (0.4)	4.8 (0.9)	1.460	2.000	0.056	3.723*
cool down	3.2 (1.6)	3.0 (1.3)	3.6 (0.7)	3.6 (1.2)	3.9 (1.0)	3.9 (0.9)	0.847	0.525	2.139	0.213
dynamic stretch	3.5 (1.1)	3.6 (1.1)	3.7 (0.9)	3.4 (1.3)	4.3 (0.8)	4.5 (0.7)	4.999**	5.944**	0.362	7.815**
static stretch	2.6 (1.3)	2.5 (1.4)	3.1 (1.2)	3.0 (1.4)	3.2 (1.3)	3.0 (1.5)	2.214	0.689	5.774**	1.235
core stability	4.0 (1.0)	4.0 (0.9)	4.1 (0.6)	4.1 (1.1)	4.4 (0.6)	4.5 (1.0)	0.617	0.896	0.000	0.906
balance	3.4 (1.3)	3.5 (1.2)	3.5 (1.1)	3.5 (1.2)	4.1 (0.9)	4.3 (0.9)	1.993	1.995	0.178	3.363*
strength upper limbs	3.6 (1.2)	3.6 (1.2)	3.5 (1.0)	3.5 (1.1)	3.8 (1.0)	4.1 (0.8)	1.516	0.389	2.055	2.740
strength lower limbs	4.0 (0.8)	3.9 (0.9)	3.8 (0.5)	3.8 (0.9)	4.1 (0.9)	4.3 (0.9)	3.649**	2.004	1.506	7.658**

p*<0.1, p**<.05, ***p<.01

An overall time by group interaction effect was seen for teachers' engagement in preventive behavior when they were active themselves. The possibility to combine different strategies at once (e.g. performing dynamic stretch while warming up) explains the larger mean sum score of 63.2min during a training of 60min. Positive evolutions in core stability, balance and strength in upper limbs were found (table 2).

Table 2. Preventive behavior of PE teachers (control and intervention group) in own extracurricular sporting activities (OWN), expressed as mean amount of minutes per training of 60 minutes, over time.

	Control group			Intervention group			Interaction effect			
	Mean score (± SD)			Mean score (± SD)			F-value			
	pre	post	follow-up	pre	post	follow-up	pre-post-follow-up	pre-post	post-follow-up	pre-follow-up
OWN	32.1 (24.9)	31.2 (17.9)	35.6 (19.6)	33.3 (29.3)	55.2 (30.1)	63.2 (41.4)	1.677**	0.967	1.087	0.912
correct performance	3.7 (3.1)	4.3 (3.5)	1.7 (2.1)	4.3 (5.7)	7.5 (6.1)	6.0 (6.3)	0.726	0.398	1.120	2.364
warm up	11.0 (10.9)	12.0 (10.2)	7.8 (5.4)	11.4 (8.4)	13.6 (8.9)	15.4 (12.9)	0.776	0.000	0.493	0.159
cool down	3.1 (3.2)	2.9 (2.9)	5.1 (4.0)	3.2 (2.3)	4.5 (3.2)	6.7 (6.5)	0.248	0.674	0.220	0.256
dynamic stretch	0.9 (1.2)	1.3 (2.2)	2.7 (2.4)	3.3 (3.2)	5.8 (4.9)	7.8 (6.2)	0.594	1 236	0.077	0.002
static stretch	2.4 (2.3)	2.8 (2.3)	3.7 (2.7)	3.5 (2.7)	4.4 (3.9)	5.9 (5.2)	0.004	0.000	0.609	0.414
core stability	3.9 (3.8)	2.6 (2.1)	3.9 (3.7)	2.6 (3.3)	5.9 (5.0)	7.7 (7.4)	2.865*	4.508*	0.051	0.967
balance	1.7 (2.0)	1.2 (1.3)	1.0 (1.5)	1.1 (1.8)	5.1 (3.9)	5.6 (5.4)	3.903**	6.195**	0.033	6.126**
strength upper limbs	2.7 (3.0)	2.5 (2.4)	5.2 (6.2)	2.1 (2.6)	4.1 (3.7)	3.3 (2.7)	1.335	0.197	3.037*	0.546
strength lower limbs	2.7 (3.3)	1.6 (2.4)	4.5 (6.5)	1.8 (2.6)	4.3 (4.3)	4.8 (4.2)	1.046	2.507	0.176	0.769

p*<0.1, p**<.05, ***p<.01

In PE lessons towards the students

PE teachers reported a higher utility score from pre to post and from pre to follow-up. Positive evolutions were found for correct performance, cool down and dynamic stretch (table 3).

Table 3. Perceived utility of the provided strategies in PE lessons towards the students (IN PE), expressed as a mean score on a maximum score of 5, in both control and intervention group over time.

	Control group			Intervention group			Interaction effect			
	Mean score (± SD)			Mean score (± SD)			F-value			
	pre	post	follow-up	pre	post	follow-up	pre-post-follow-up	pre-post	post-follow-up	pre-follow-up
IN PE	3.6 (0.6)	3.5 (0.6)	3.7 (0.4)	3.6 (0.8)	3.9 (0.6)	4.1 (0.8)	1.407	2.302**	0.169	2.508**
correct performance	4.5 (0.8)	4.0 (1.1)	4.2 (0.6)	4.2 (1.1)	4.2 (1.0)	4.5 (0.7)	2.698*	6.022**	0.118	4.112*
warm up	4.5 (0.5)	4.5 (0.6)	4.5 (0.5)	4.6 (0.8)	4.5 (0.8)	4.7 (0.5)	0.306	0.001	0.077	0.500
cool down	3.1 (1.5)	3.2 (1.1)	3.2 (1.0)	3.0 (1.2)	3.6 (1.2)	3.8 (0.6)	1.970	1.863	0.271	4.465**
dynamic stretch	3.8 (0.6)	3.6 (1.1)	3.8 (0.8)	3.4 (0.9)	4.2 (0.9)	4.4 (0.8)	9.020***	11.527**	0.489	15.595***
static stretch	2.5 (1.2)	2.7 (1.2)	2.8 (1.2)	2.8 (1.2)	3.2 (1.4)	3.3 (1.2)	0.205	0.125	0.062	0.556
core stability	4.0 (1.1)	3.7 (0.7)	3.9 (1.1)	3.9 (1.0)	3.9 (0.7)	4.2 (0.8)	0.768	2.239	0.027	0.955
balance	3.1 (1.2)	3.3 (1.0)	3.6 (0.8)	3.3 (1.0)	3.8 (0.9)	4.2 (0.6)	0.530	0.018	0.037	1.166
strength upper limbs	3.4 (1.1)	3.2 (1.0)	3.4 (1.3)	3.3 (0.8)	3.6 (1.0)	3.8 (1.2)	0.688	2.032	0.000	0.861
strength lower limbs	3.4 (1.0)	3.4 (0.9)	3.6 (1.2)	3.5 (0.9)	3.9 (0.8)	4.1 (0.6)	0.742	2.202	0.710	1 075

p*<0.1, p**<.05, ***p<.01

Moreover, an overall time by group interaction effect was found for the amount of time spent on preventive behavior in PE lessons. Also pre to post and pre to follow-up changes were reported. Positive evolutions were seen in all, but one, namely static stretch, preventive strategies (table 4).

Table 4. Preventive behavior of PE teachers (control and intervention group) in PE lessons towards the students (IN PE), expressed as mean amount of minutes per PE lesson of maximum 50 minutes, over time.

	Control group			Intervention group			Interaction effect			
	Mean score (± SD)			Mean score (± SD)			F-value			
	pre	post	follow-up	pre	post	follow-up	pre-post-follow-up	pre-post	post-follow-up	pre-follow-up
IN PE	24.7 (18.3)	21.9 (21.6)	20.1 (15.9)	19.0 (13.9)	31.3 (21.4)	37.9 (21.0)	1.833**	1.888*	0.841	3.239**
correct performance	6.7 (5,9)	4.3 (5,2)	4.6 (7.3)	3.2 (3.1)	6.0 (4.6)	6.8 (5.7)	6.886**	9.036**	0.113	8.724**
warm up	6.5 (3.1)	6.9 (4.6)	6.3 (2.6)	6.2 (3.9)	7.6 (5.5)	8.7 (5.3)	2.512*	0.759	1.432	6.807**
cool down	1.6 (2.1)	2.1 (2.5)	1.7 (1.7)	1.6 (2.0)	2.4 (3.0)	2.9 (2.9)	2.122	0.430	1.618	3.783*
dynamic stretch	1.6 (1.6)	1.6 (1.8)	1.5 (1.4)	1.9 (2.2)	2.8 (2.6)	4.0 (2.8)	6.208*	2.519	4.880*	9.063
static stretch	1.5 (1.9)	1.2 (1.8)	1.4(1.9)	1.4 (1.4)	1.6 (2.0)	2.0 (2.0)	1.498	1.873	0.684	2.287
core stability	2.0 (2.4)	1.3 (2.4)	0.9 (1.5)	1.4 (2.1)	2.9 (2.6)	3.1 (3.1)	5.957**	10.266**	0.617	7.912**
balance	1.2 (2.3)	1.7 (3.2)	0.7 (1.2)	0.7 (1.2)	2.8 (2.1)	3.0 (2.6)	6.874**	5.185**	2.132	14.215**
strength upper limbs	1.9 (2.8)	1.3 (2.1)	1.4 (2.3)	1.3 (1.6)	2.3 (2.6)	3.0 (2.8)	3.883**	4.640**	0.690	5.012**
strength lower limbs	1.9 (2.9)	1.4 (2.3)	1.6 (2.9)	1.4 (1.8)	2.8 (2.9)	4.4 (3.4)	6.060**	5.547**	2.595	6.173**

p*<0.1, p**<.05, ***p<.01

In trainings towards the adolescent athletes

No significant overall changes were found for perceived utility of the strategies in trainings over time. Only one positive change in correct performance was found in intervention group compared to the controls (table 5).

Table 5. Perceived utility of the provided strategies in trainings towards athletes (IN TR), expressed as a mean score on a maximum score of 5, in both control and intervention group over time.

	Control group (n=10)			Intervention group (n=12)			Interaction effect			
	Mean score (± SD)			Mean score (± SD)			F-value			
	pre	post	follow-up	pre	post	follow-up	pre-post-follow-up	pre-post	post-follow-up	pre-follow-up
IN TR	4.1 (0.6)	4.2 (0.5)	4.3 (0.4)	4.2 (0.9)	4.5 (0.7)	4.7 (0.4)	0.588	0.618	0.627	0.631
correct performance	4.6 (0.7)	4.8 (0.5)	4.5 (0.5)	4.4 (1.3)	4.9 (0.3)	5.0 (0.0)	1.245	0.555	5.054**	1.294
warm up	4.6 (0.5)	4.8 (0.5)	4.6 (0.5)	4.5 (1.3)	4.9 (0.3)	4.9 (0.3)	0.963	0.393	1.106	1.534
cool down	3.8 (0.9)	4.0 (0.9)	3.9 (0.6)	3.8 (1.5)	4.0 (1.5)	4.3 (0.8)	0.313	0.021	0.334	0.822
dynamic stretch	4.1 (0.8)	4.4 (0.7)	4.5 (0.8)	3.8 (1.5)	4.6 (0.7)	4.8 (0.4)	1.005	1.269	0.341	0.320
static stretch	2.8 (1.0)	3.6 (0.9)	3.4 (1.3)	3.9 (1.0)	4.2 (1.1)	4.3 (0.8)	0.581	2.981	0.608	0.235
core stability	4.4 (0.9)	4.1 (0.6)	4.4 (0.5)	4.5 (1.3)	4.5 (1.0)	4.8 (0.4)	0.377	0.568	0.327	0.028
balance	4.1 (0.8)	4.3 (0.5)	4.3 (0.7)	4.3 (0.9)	4.4 (1.0)	4.9 (0.3)	0.902	0.009	0.801	1.705
strength upper limbs	4.0 (0.8)	4.1 (0.4)	4.3 (0.5)	4.1 (1.1)	4.5 (1.0)	4.6 (0.7)	0.193	0.680	0.000	0.012
strength lower limbs	4.1 (0.6)	4.0 (0.5)	4.4 (0.5)	4.4 (1.3)	4.2 (0.9)	4.9 (0.3)	0.291	0.105	1.174	0.011

$p^{*}<0.1$, $p^{**}<.05$, $^{***}p<.01$

An overall time by group interaction effect was found for implementing preventive behavior in trainings. Positive evolutions in correct performance and warm up were reported (table 6).

Table 6. Preventive behavior of PE teachers (control and intervention group) in trainings towards athletes (IN TR), expressed as mean amount of minutes per training of 60 minutes, over time.

	Control group (n=8)			Intervention group (n=9)			Interaction effect			
	Mean score (± SD)			Mean score (± SD)			F-value			
	pre	post	follow-up	pre	post	follow-up	pre-post-follow-up	pre-post	post-follow-up	pre-follow-up
IN TR	37.8 (21.1)	36.6 (16.5)	36.6 (16.0)	31.7 (21.5)	45.6 (22.8)	48.2 (28.1)	1.780**	2.409	0.379	2.032
correct performance	3.1 (3.3)	3.9 (3.9)	3.5 (2.5)	3.1 (2.8)	4.4 (3.3)	5.3 (3.6)	1.957	0.363	2.081	3.313*
warm up	9.0 (4.7)	8.5 (3.0)	9.1 (3.2)	7.8 (5.0)	13.1 (8.9)	13.3 (12.9)	2.820*	5.550**	0.058	2.283
cool down	3.0 (3.0)	3.5 (2.9)	3.4 (1.9)	3.0 (2.4)	3.4 (3.0)	3.9 (5.0)	0.153	0.005	0.274	0.126
dynamic stretch	2.9 (2.6)	3.1 (2.4)	2.9 (2.2)	2.8 (2.6)	4.0 (3.0)	5.2 (4.0)	1.487	0.438	0.678	7.872
static stretch	3.1 (2.5)	2.9 (1.6)	2.6 (1.3)	2.2 (2.0)	2.8 (2.5)	3.0 (2.2)	0.863	0.575	0.673	1.133
core stability	4.1 (4.0)	2.9 (2.3)	3.6 (2.6)	3.1 (3.4)	4.1 (3.2)	4.0 (2.5)	2.040	2.691	1.166	1.515
balance	3.0 (2.6)	2.4 (1.5)	2.9 (1.8)	3.3 (3.1)	4.8 (3.3)	4.1 (2.3)	1.878	2.773	1.351	0.918
strength upper limbs	4.3 (3.5)	5.4 (6.5)	4.9 (4.9)	2.2 (2.9)	3.4 (3.4)	4.0 (4.1)	0.348	0.003	0.388	1.037
strength lower limbs	5.3 (4.6)	4.1 (3.5)	3.8 (3.2)	4.1 (5.1)	5.4 (4.3)	5.3 (3.5)	1.332	1.082	0.120	1.857

$p^{*}<0.1$, $p^{**}<.05$, $^{***}p<.01$

Discussion

In previous studies (Vercruysse et al., 2016a; in revision) with more limited samples (n=20; n=14 PE teachers), we provided initial evidence to show that NGWP results in improvements in teachers' injury preventive knowledge. Similar results were found in the present study (aim 1). These results are encouraging, as it is known that knowledge is related to a positive attitude of sport injury prevention (Wang et al., 2012).

Secondly, after teachers participated in the intervention, they perceived the strategies as more utile for their own sporting activities. In a previous study in PE teachers (Vercruysse et al., 2016a), perceived utility showed similar positive changes, however no control group was included in that study. Also, whereas improvements were seen already from pre to post in a previous study (Vercruysse et al., 2016a), in the current study, mainly changes from pre to follow-up were reported. It might be possible that after receiving the intervention, PE teachers had the impression they received an overload of information and the utility was not yet fully understood. However, after delving into how to tackle the information, they indicated an increased utility. According to SDT (Deci and Ryan, 2000), the willingness to engage in the proposed strategies will be higher when participants understand the personal usefulness of the preventive strategies (Aelterman et al., 2013), so these positive evolutions are encouraging.

The actual engagement in the preventive behaviors in their own sporting activities increased as well with 21.9min/60min from pre to post, and another 8min at follow-up. Apart from increases in time spent in preventive behaviors, it is perhaps even more important that teachers use a wider variety of strategies (Vercruysse et al., 2016b; in revision). Although, in the present study, all preventive strategies tend to show a larger implementation after receiving the intervention, differences were mainly found for core, balance and strenght in the upper limbs. This is not so surprising, as warming-up with dynamic stretch (CON: 11.9; INT: 14.7min) and cooling down with static stretch (CON: 5.5min; INT: 6.7min) are activities that teachers already more frequently engage in at baseline, while balance, core and strength training are barely used (minimum 1.1min and maximum 3.9min). These positive results are in line with those of a previous study of Vercruysse et al. (under revision).

After receiving the intervention, PE teachers experienced the provided strategies not only as more useful to implement when engaging in sport themselves, they also rated them as more useful for their PE lessons. The many provided ready-to-use exercises in the form of didactical posters, the provision of a rationale during the theoretical part of the training, and the opportunities to practice the exercises during the practical part may have contributed to this positive finding. Moreover, 2-3 weeks after receiving the intervention, PE teachers increased the implementation of preventive strategies in their PE lessons (of maximum 50min) with 12.3min and 8-9 weeks after receiving the intervention this increase was already 18.9min. These results confirm that NGWP is effectively training PE teachers to implement injury prevention into their PE lessons (also see Vercruysse et al., in revision). On top, positive changes were found for all, but one (static stretching) preventive strategy. This indicates a balanced improved implementation of all strategies in PE lessons, which was what we were aiming for (Vercruysse et al., 2016b). To illustrate, the combination of 2.9min cooling down with 2.0min of static stretch is meeting the requirements of a total duration of minimum 5min for cooling down in order to be effective in reducing injuries (Malliou et al., 2007).

Lastly, no changes were found for perceived utility of the provided strategies in teachers' trainings towards athletes. Explanations can be found in the high initial scores of perceived utility at baseline (4.2 on a maximum score of 5) in comparison to those in own sporting activities (3.8) or in PE lessons (3.6). It seems that PE teachers, also active as a trainer, were already convinced of the utility of implementing preventive strategies towards athletes in a sports club. Nevertheless, the current study showed that the effective implementation of the preventive strategies in trainings can still be augmented by 16.5min/60min training through teachers' participation in the intervention. The autonomously motivating delivery approach, based on SDT, might be one of the factors stimulating this increase (Chan and Hagger, 2012). The brainstorm session to share ideas with other participants concerning the possibilities of making the preventive exercises sport specific (e.g. performing a spike in volleyball prior to training the correct jump landing technique) may also have contributed to this implementation. Making the exercises more attractive and sport-related during trainings is a concern of most coaches to avoid drop out in sports, as "a lack of enjoyment", "not having fun" and "being bored"

are most reported intrapersonal constrains in children and youth (Crane and Temple, 2015). An explanation of the larger initial implementation in trainings, compared to implementation in PE lessons, may be due to the great desire to win (e.g. athletes have to become “faster, higher and stronger” to reach the top) among athletes in a sports club. Adolescents active in a sports club exercise on average 4h/week, in which trainers can more easily include preventive strategies (Jekauc et al., 2013). In trainings, correct performance improved from pre to follow-up and warm up improved from pre to post. As trainings in different sports require different needs (e.g. adapted stretching in different sports; Witvrouw et al., 2004) and differentiation towards the athletes’ individual needs is more feasible at trainings, an overall augmented implementation at training might predict an injury reduction.

Strengths and limitations

The strength of this study is implementing injury prevention through PE teachers in three target populations and settings; PE teachers in own sport activities, in their PE lessons at school and when they are active as a sport trainer in the sport club. Moreover, the combination of measuring knowledge, perceived utility and executed behavior in a RCT design provides a good overview of the changes caused by the intervention and gives insight in the underlying mechanisms.

A limitation in this study is that the quality of the strategies was not recorded. In 2014, Fortington et al. developed an observational tool to assess the quality of exercise performance by technique, volume and intensity in an injury prevention program. A similar tool can be used in the future to assess the quality of the provided exercises. Despite the increases in preventive behavior, a different interpretation of preventive strategies may occur between both groups after receiving the intervention. For example, controls may report to perform four minutes of core stability, but perhaps include exercises which are detrimental for the back (e.g. sit-ups; Childs et al., 2010). This may even enlarge the obtained effect. Another limitation is the fact that no preventive behaviour measurements in adolescents were assessed. However, in a previous study was shown that measurements of students are in line with those of the teachers (Vercruysse et al., in revision). And last, but not least, no injury incidences were

recorded in the three target populations. Injury registrations during a longer period of time and in a larger sample would make it possible to have insight in the occurrence of injuries in the three target populations. However, in order to reach the latter, a reliable registration system should be developed.

Perspectives

By use of the adapted version of NGWP in the current study, injury preventive strategies can be delivered through PE teachers, whether or not active as trainers, towards adolescent athletes.

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GENERAL DISCUSSION

1. The conceptual model of the current dissertation

The current dissertation aimed to contribute to effective injury prevention among a multi-sport adolescent population through PE teachers. The conceptual model of De Clercq et al., (2011; figure 1) served as the basis to realize this aim. The arrows in the model, show different pathways through which this aim can be realized. Direct pathways (↗) refer to training PE teachers to effectively implement injury prevention in their PE lessons. Indirect pathways refer to the transfer of injury preventive knowledge and behavior to the sport club. This transfer can occur through the PE teachers who are active as sports trainers and thus implement injury prevention strategies in their activities as a sport trainer (⇢), but can perhaps also occur through the students who are active as sport participants (⇢). Apart from this last pathway (i.e. students in PE to sport active youngsters), all pathways of the model were tested in this dissertation and will be discussed in what follows.

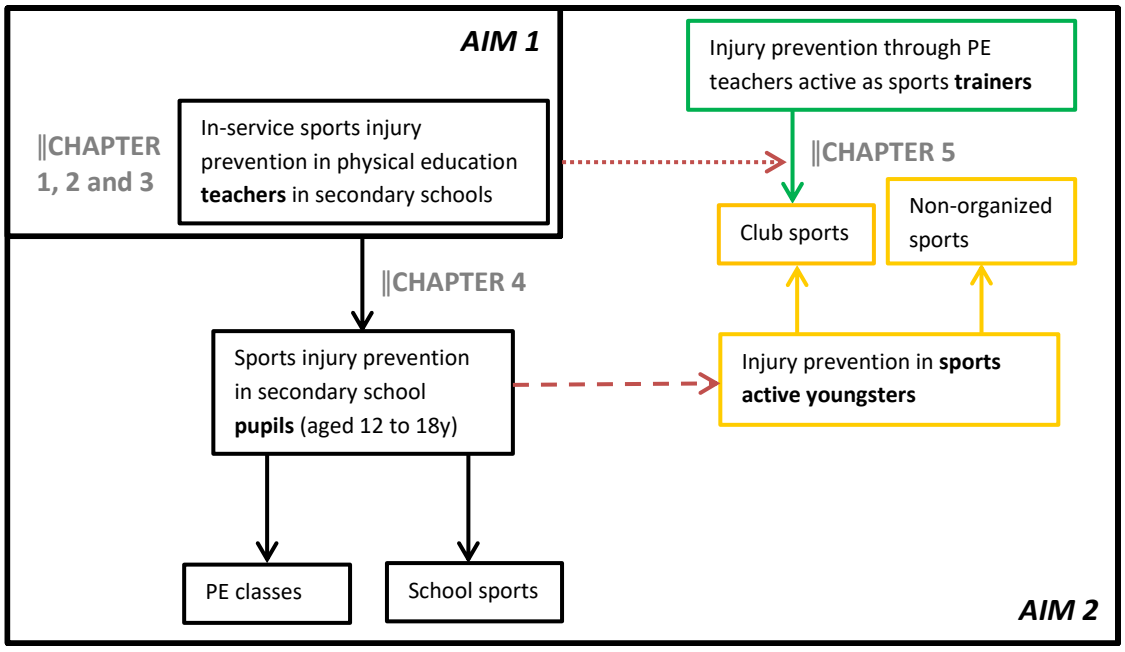

Figure 1. An overview of the different target populations in this dissertation with indication of the five chapters and two aims, based on the conceptual model of De Clercq et al. (2011).

To investigate this conceptual model, three intervention studies were designed to train PE teachers to effectively implement injury prevention strategies in their own lives (chapter 3, 4, 5), in their PE lessons (chapter 4, 5), and in their coaching activities (chapter 5). Prior to setting up these larger scale intervention studies, two preparatory studies were conducted

that served as a foundation for each of the three intervention studies. One study enriched our knowledge on the epidemiology of injuries in Flemish PE teachers (chapter 1), while the second study provided insights into which optimizations were needed for the NGWP intervention to meet PE teachers needs and wishes (chapter 2). Overall, these five studies contribute to the realization of two main aims:

1) Optimization of a primary multifactorial injury prevention intervention so that it is well-appreciated and effectively increases physical education teachers' injury prevention competences and lower their injuries.

2) Pursuit of injury prevention implementation in sports active adolescents through physical education teachers transferring the prevention strategies in their lessons and/or in training at club level.

2. Summary of the main results

It has been shown in the literature that multifactorial injury prevention interventions can lower the occurrence of musculoskeletal injuries in sport-specific populations (Parkkari et al., 2001). The results of many effective multifactorial injury prevention interventions (e.g. Aerts et al., 2013; Arnason et al., 2008; Emery et al., 2005; Olsen et al., 2005) formed the basis for the so called "No Gain With Pain" intervention, initially developed for PETE students (Goossens et al., 2015a). As the latter intervention is based on an extensive literature review (Goossens, 2015b) and is one of the first to offer a multifactorial injury prevention intervention in a multisport population, the program formed a good basis for the studies in this dissertation. Yet, optimization of the program according to PE teachers' needs was wanted.

Although there was some evidence available on the epidemiology of PE teachers in the literature (Pihl et al., 2002; Kovač et al., 2013; Andre et al., 1991; Lemoyne et al., 2007; Sandmark et al., 2000), existing studies suffered from methodological limitations (e.g. lack of prospective design, no reference group). In addition, no studies were available in Flemish PE teachers. In order to gain further insight into the epidemiology of Flemish PE teachers, a first study (chapter 1) was designed. In this study, with a prospective design, injury incidence among 103 PE teachers was compared to a reference population, namely 58 non-PE teachers. PE teachers sustained 1.23 injuries/ teacher/ school year, which was higher than non-PE teachers (0.78 injuries/ teacher/ school year). Most injuries in PE teachers were first-time (51%), non-contact (76%) and acute (62%). The most affected body parts were the back (18.8%) and knees (17.3%). From this study we learned that compared to non-PE teachers, PE teachers had a more extensive injury history, practiced more sports, had a higher sport- and work index and taught more extra-curricular sports, suggesting injury prevention is highly needed in the population of PE teachers. The results of this first study (Chapter 1) could be used to further shape the content of the NGWP program so that it better fitted the context of the target population of PE teachers. This was realized by focusing on PE teachers main injured body parts (i.e. lower limb, back and shoulder) and by focusing on the identified injury risk factors (i.e. injury history, recurrent injuries for 48%). The "adapted NGWP 1.0" program consisted of a theoretical part (3h) and practical part (3.5h) in which eight preventive strategies were covered and SDT (Deci and Ryan, 2000) formed the

theoretical basis in which the delivery approach was grounded (e.g. starting with an introducing round, posing many questions, allow choices in exercises, incorporate success experiences, etc.).

After that, it was decided to further revise the "adapted NGWP 1.0" program so that it optimally fits the needs and wishes of PE teachers. To do so an optimization study with 20 PE teachers was designed, in which three cycles of implementation (PE teachers receive the intervention), evaluation (PE teachers express their appreciation of the intervention) and optimization (researchers adapt the intervention), allowed to gradually improve the NGWP program which was reflected in the high and increasing appreciation of the intervention by PE teachers after each adaptation (chapter 2). For example, in the theoretical part of the intervention a more enjoyable and attractive approach was used to excite the teacher's interest (e.g. adding quiz questions and giving small practical try outs). In the practical part, one of the changes was adapting the didactical posters according to teachers' suggestions (e.g. adding different levels and frequencies, making active muscle groups visible in the drawings, changing the organization of images and text). Also appreciation scores for interaction (4.13 (cycle 1) to 4.00 (cycle 2) to 5.00 (cycle 3) on a maximum score of 5.00), intelligibility (4.07 to 4.29 to 4.50), innovation (4.00 to 3.29 to 4.40), practical usefulness (3.88 to 4.14 to 4.80), and recommendation of the intervention towards others (4.25 to 4.00 to 4.80), improved as a result of the optimizations made. Further declarations of the appreciation scores could be found in the promising comments during the focus group conversations (e.g. "In the beginning, during completion of the questionnaire, I did not have much enthusiasm, but once the theoretical part started I was immediately motivated thanks to the use of different interactive methods."). Moreover, in this study perceived utility of the strategies increased from 4.05 (pre; before the first training in February-March) to 4.73 (post; before the second training in April-May) to 4.48 (follow-up; in June) and also confidence to apply the strategies (3.75 to 3.96 to 4.26) and teachers' knowledge about prevention strategies (5.0 to 7.1 to 6.8 on a maximum score of 10) were found to increase over time.

In chapter 3 we evaluated the effectiveness of the "adapted NGWP 1.0" program through a randomized-controlled trial with 55 PE teachers being randomly allocated to an intervention or control group. All PE teachers completed weekly registrations, concerning the occurrence

of injuries and their engagement in preventive behaviors during one school year. The intervention was found to be effective in reducing injury incidence in PE teachers in the intervention group (0.49 injuries/ 1000h time of exposure) compared to control group (1.14 injuries/ 1000 h TOE). Effects were mainly found in the reduction of non-contact injuries, which are not coincidentally the kind of injuries most common in PE teachers (chapter 1). The amount of time performing preventive behavior did not differ between intervention and control groups, however a more balanced use of the strategies was seen in the intervention group with PE teachers of the intervention group engaging more frequently in dynamic and static stretching, core stability, balance and strength training compared to the control group who mainly engaged in warming-up.

Together chapters 1-3 allowed for the optimization of the existing multifactorial injury prevention intervention, NGWP, so that it could be delivered to PE teachers and was effective in increasing teachers' injury prevention competences and lowering their injuries (aim 1).

Then, to reach the second aim, in chapter 4, a randomized controlled trial was designed with 14 PE teachers and 271 pupils, which were randomly assigned to an intervention or control group. PE teachers in the intervention group received the "adapted NGWP 2.0". In this intervention the following modules were added to specifically target transfer to the pupils in the PE lessons: The content of each part was expanded addressing how teachers can include the strategies in their PE lessons (e.g. an attractive memory game with functional strength exercises was provided). Supplementary examples on how preventive strategies could be integrated in sport-specific lessons (e.g. standing on one leg, while trying to pull a handball out of the hands of the other) were also provided. PE teachers also received adapted versions of the existing didactical posters (see chapter 2 and 3) that could be used by their pupils during PE (e.g. the amount of didactical posters was expanded to obtain more variation and a wider range of exercises, suggestions of repetitions and sets of exercises were adapted to pupils' level, and on the back side of the didactical poster a figure indicating the active muscle(s) during that specific exercise was added). Besides suggestions provided as part of the intervention, PE teachers had the opportunity during the training to figure out themselves how they would implement the preventive strategies in PE lessons and how to make it topic-related (i.e. increasing their autonomy). To do so, brainstorm exercises were

added where PE teachers could share ideas on how to implement the strategies in PE. In accordance with previous chapters (2 and 3), an SDT-based delivery approach was thus used to motivate PE teachers to implement strategies both in their own lives as in their PE lessons.

PE teachers' injury prevention knowledge increased after receiving the "adapted NGWP 2.0" program (INT: 3.7 to 6.5 to 6.9), whereas this remained the same in the controls (CON: 3.5 to 4 to 3.8). The increasing results in chapter 4 are perfectly in line with those of chapter 2 (5.0 to 7.1 to 6.8) indicating that after adjusting the program, increases in PE teachers' knowledge were still obtained. After receiving "adapted NGWP 2.0" PE teachers also engaged more frequently in preventive behavior when playing sport themselves (INT: 26.8 (pre) to 48.6 (post) to 37.1 (follow-up) min per sporting activity of 60 min CON: 32.6 to 16.6 to 18.4). PE not only engaged in the preventive strategies more frequently, they also engaged more in dynamic and static stretching, core stability, balance, and strength training. Moreover, an augmented use of warming up and cooling down was also reported, which indicates an improvement of all provided preventive strategies. These results of NGWP 2.0 seem even more convincing then the results found when assessing the effectiveness of NGWP 1.0 (Chapter 3) as we not only found a more balanced, but also a more frequent use of the preventive strategies.

Most important to chapter 4, the "adapted NGWP 2.0" program effectively increased the application of injury prevention strategies in teachers' PE lessons (INT: 33.6 to 45.4 to 68.3 min per PE lesson of 50 min; CON: 40.6 to 29.3 to 28.1 min). Differences between intervention and control group were found for warming up and dynamic stretching. Static stretching showed a decrease over time in both groups, but the decline was steeper in the control group. Even so, pupils also reported seeing a positive evolution in warming up and more decreasing evolution in static stretching. Pupils also reported an increased use of functional strength training in upper and lower limbs. The latter also tends to increase in the reports of PE teachers themselves (2.3 to 4.0 to 3.4 min per PE lesson) although differences were not significant, because also in the control group results were not constant (0.9 to 3.4 to 0.0 min). There were some disparities in the teacher and students reports, but comparisons are difficult to make because assessments were completed with different rating scales in PE teachers (exact number of minutes per preventive strategy per PE lesson) and in

pupils (three assessment moments on a Likert-scale of 1 to 5). With this fourth study it was shown that it is possible to effectively train PE teachers to implement preventive strategies into their PE lessons. Yet, the effects on teachers' PE lessons were limited to only a number of strategies, and it was not known yet if this behavioral change is also possible in training contexts and therefore a final study was designed. Both issues were addressed in chapter 5.

In the "adapted NGWP 3.0" intervention, the following modules were added to specifically target transfer to adolescent athletes active in a sports club: The SDT based delivery approach was applied to not only autonomously motivate PE teachers to increase their preventive behavior, but PE teachers were also informed about how to autonomously motivate adolescents towards injury preventive behavior in both PE lessons and at training level. Specifically, the present intervention added a brainstorm session of 45 min, where PE teachers could discuss and be creative about implementing SDT-based principles (e.g. implementing choice) in their PE lessons and also in their training sessions. Stimulation of the implementation of the provided preventive strategies at training level in sports clubs was realized by providing interactive teaching methods and offering organizational changes to show how the basic exercises (provided in a folder of 136 didactical posters) could be made more sport specific. Additionally, to obtain interaction among PE teachers/trainers after receiving the intervention, and to stimulate them to share ideas and good practices a secured Facebook page was launched.

In this randomized controlled trial 49 PE teachers were randomly assigned to an intervention (n=25) or control group (n=24). Three main outcomes were measured, namely injury preventive knowledge, preventive behavior (in their own extra-curricular sporting activities, in PE lessons and in training) and perceived utility of the provided preventive strategies in the three contexts. This study confirmed that, as in chapter 2 and 4, the "adapted NGWP 3.0" program resulted in improvements in PE teachers' injury preventive knowledge (INT: 4.2 to 7.0 to 5.8; CON: 5.2 to 4.5 to 4.9). In line with the results of chapter 2, perceived utility of the provided strategies improved in relation to their own sporting activities (INT: 3.8 to 4.1 to 4.2; CON: 3.7 to 3.7 to 3.8). Moreover, increased utility scores for the implementation of the strategies in teachers' PE lessons were also reported (INT: 3.6 to 3.9 to 4.1; CON: 3.6 to 3.5 to 3.7), but no increases were found for perceived utility of the strategies in trainings (INT: 4.2 to 4.5 to 4.7, CON: 4.1 to 4.2 to 4.3). Explanations for the latter can be found in the

high utility scores in trainings at baseline. Most importantly, this study confirmed that the "adapted NGWP 3.0" resulted in an increased application of the provided strategies in teachers' own sporting activities (INT: 33.3 to 55.2 to 63.2 min/60 min training; CON: 32.1 to 31.2 to 35.6 min), as well as in their PE lessons (INT: 19.0 to 31.3 to 37.9 min/50 min PE lesson; CON: 24.7 to 21.9 to 20.1 min). Moreover, while the "adapted NGWP 2.0" (Chapter 4) only resulted in improvements in warming up and dynamic stretching the "adapted NGWP 3.0" resulted in improvements in a wider range of strategies: correct performance, cool down, core stability, balance and strength in upper and lower limbs. The provision of interactive teaching methods and organizational changes to show how the basic exercises could be made sport specific, may have increased the use of each preventive strategy in PE lessons as well. Again, no improvements in static stretching were reported. Additionally, this fifth study showed that it was possible to improve implementation of the provided strategies in trainings with 16.5 min per training of 60 min (INT: 31,7 to 45.6 to 48.2 min/60 min training; CON: 37.8 to 36.6 to 36.6 min), in which positive evolutions for correct performance and warming up were found.

With the latter two studies (chapter 4 and 5), injury prevention in a multi-sport adolescent population was reached by training PE teachers to effectively transfer the prevention strategies in their PE lessons and/or in trainings at club level (aim 2).

Table 1 provides an overview of the five studies (and chapters) in this dissertation with a summary of the main characteristics and results.

Table 1. Overview of the 5 studies and chapters in this dissertation with aims, sample sizes, design and summary of the results.

	Study	Aim	Sample	Design	Main Results
Sept - June '12 '13	1	Understanding the extent, characteristics and underlying factors of injuries in PE teachers	103 PE teachers and 58 non-PE teachers	Weekly prospective registrations of injuries	1.23 injuries/PE teacher/school year which was higher than the referents. Mostly first-time, acute and non-contact injuries. Lower limbs, knee and back most injured
Feb - June '13	2	Optimize an injury prevention intervention for PE teachers (adapted NGWP 1.0)	20 PE teachers	Cycles of implementation, evaluation and optimization	The injury prevention intervention could be optimized based on qualitative and quantitative feedback and the intervention was well appreciated by the target population of PE teachers
Sept - June '13 '14	3	Testing the effectiveness of the optimized injury preventive intervention (adapted NGWP 1.0)	CON: 26 PE teachers INT: 29 PE teachers	Randomized controlled trial with prospective registrations	The controls had more injuries than PE teachers from intervention group (CON: 1.14; INT: 0.49 injuries/1000 h TOE). Preventive strategies were used during the same amount of time, but with a broader variety
Jan - March '15	4	Besides previous effects, the implementation of preventive behavior in PE lessons is tested through PE teachers towards pupils (adapted NGWP 2.0)	CON: 7 PE teachers, 132 pupils INT: 7 PE teachers, 139 pupils	Randomized controlled trial with prospective registrations	Improvements in preventive knowledge, behavior in own extra-curricular sporting activities and in PE teachers' teaching behavior towards pupils was found. Reports of pupils pointed in the same direction as the reports of PE teachers
Jan - May '16	5	Adding to study 4, effects on the implementation of preventive behavior in trainings for the PE teachers who are also active as a training is examined (adapted NGWP 3.0)	CON: 24 PE teachers INT: 25 PE teachers	Randomized controlled trial with prospective registrations	Improvements in preventive knowledge and improvements in perceived utility in own sporting activities and PE lessons were reported. Increases of preventive behavior in own extra-curricular sporting activities, in teaching behavior during PE lessons and in training was reported.

CON = control group, INT = intervention group, PE = physical education, TOE = time of exposure

3. TRIPP model: Translating Research into Injury Prevention Practice

Although this dissertation started from the previously mentioned (see 1. in the general discussion) conceptual model, the studies of each chapter can equally be positioned within step one to four of the Translating Research into Injury Prevention Practice (TRIPP) model. This model was designed to be used in research, leading to real-world sports injury prevention (Finch, 2006). Finch drew inspiration from the model of Van Mechelen et al. (1992), but whereas the latter did not draw attention to implementation issues, Finch highlighted the need of injury prevention measures to be acceptable, adopted and complied with. Therefore, step five and six were added to the model. Moreover, in 2007, Cumps & Verhagen further developed a model based on this framework and added two background steps.

In figure 2 the adapted TRIPP-framework of Cumps & Verhagen (2007) is provided, with indication of the six main and two background steps, which can help to develop sports injury prevention programs. Initially, the epidemiology of injuries in the target population should be addressed (step 1), to then detect the injury risk factors and mechanisms (step 2). With the use of the previous two steps, a preventive program can be developed (step 3) and tested for its effectiveness by repeating the first step (step 4). In the final two steps of the model, motivators/barriers should be examined to determine whether or not participants would implement the preventive program in their lives (step 5). After adaptations to these motivators/barriers, the preventive program can be implemented in a real-world context and tested for its effectiveness (step 6).

When aligning the current study with the TRIPP model the PE teacher can be considered as a direct target for the different steps of TRIPP. The pupils and sports active youngsters in sports clubs, can be considered as indirect targets in step 3 and 4, where they are reached through the PE teacher/sports trainer.

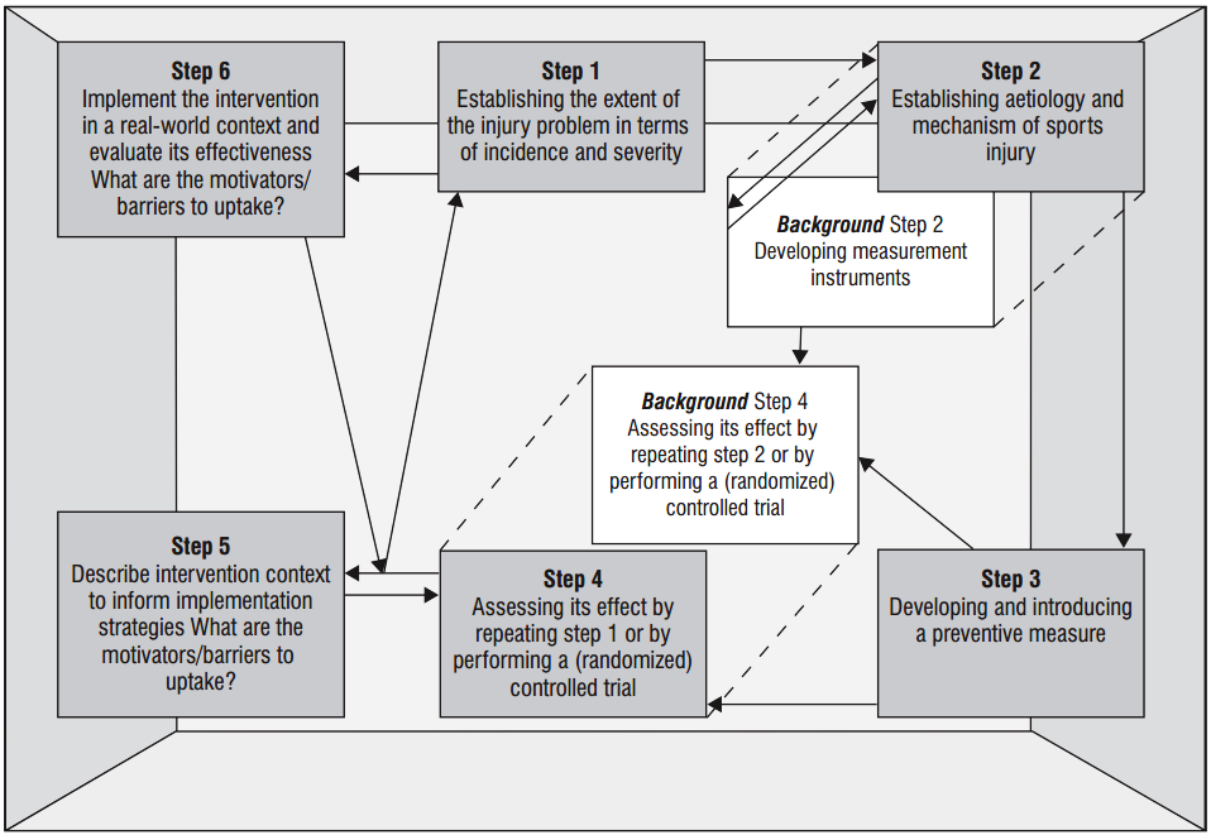

Figure 2. Adapted TRIPP-framework (in Aerts et al., 2011, adapted from Cumps & Verhagen, 2007)

3.1. Epidemiology of injuries (Step 1)

Although in the literature, few studies focus on injury incidences among PE teachers (e.g. Lemoyne et al., 2007; Pihl et al., 2002), it soon became clear that not only sport-related injuries occur in this population, but also work-related injuries are present (e.g. Sandmark et al., 1999; Andre et al., 1991). However, in the existing literature, only three studies (Sandmark, 2000; Pihl et al., 2002; Lemoyne et al., 2007) compared their results with a (small) reference population, study populations were restricted to older (Pihl et al., 2002), male (Pihl et al., 2002) or female PE teachers (White et al., 1993) and most studies were retrospective. Retrospective designs with recall periods between one year and the entire career were used, and it is well known that recall periods for musculoskeletal injuries over 12 months have a serious risk for recall bias (Gabbe et al., 2003). Therefore, a prospective epidemiologic study was designed among PE teachers (old and young, male and female) compared to a reference population of non-PE teachers during one school year (chapter 1). An injury incidence was found of 1.23

injuries/PE teacher/school year, which was higher than the values of 0.51 and 0.65 injuries/ PE teacher/ year reported by Pihl et al. (2002) and Lemoyne et al. (2007). This may be due to the retrospective character of the registrations in the latter, whereas in our study prospective registrations were used. While during retrospective questionnaires participants have the disadvantage of searching thoroughly in their memories, prospective measures have the advantage that an injury can immediately be reported. Moreover, in Pihl et al. (2002), older male PE teachers were tested and in Lemoyne et al. (2007) primary, secondary and college physical education teachers were examined. In the literature, either trunk and head (Kovač et al., 2013; Lemoyne et al., 2007), upper and lower limbs (Pihl et al., 2002) or only the lower limbs (Andre et al. 1991) were reported as the most injured body regions. In our epidemiologic study (chapter 1) mostly lower limbs (53.5%) were injured with the knee (17.3%) being injured the most. Subsequently, the back (18.0%) and shoulder (6.3%) were most affected body parts. Although White et al. (1993) found that sprains, vertebral pain and fractures were the most common, in our study inflammatory injuries (21%), strains (16%) and joint-nerve problems (11%) were most reported. Sprains were reported for seven percent and fractures five percent. The classification of injury types was different across various studies and may have led to divergent results. In the present dissertation self-reports were used, which rely on an indication of injury type by the teachers themselves. If no medical assistance was asked for, it might sometimes be difficult to indicate a correct injury type. The same questionnaire was assessed in physical education teacher education students and showed that information concerning the type of injury was proven not to be valid (Cramer's V = 0.447; P = 0.066; Goossens et al., 2013). However in the present dissertation the participants are more experienced with injuries during their education and sports and work careers. Also three researchers (DDC, LG and myself) of the department of movement and sports sciences reviewed each individual registration of injury and rated the classification of injury type, but expansion of this evaluation with a (sports) physician and physiotherapist may improve the assessment. Together with the latter, a validity check should be of added value in future research.

In adolescents, the epidemiology of injuries is well known and is described in the general introduction of this dissertation (1.1. Sports injury incidence of adolescents). Injury

incidences of 1.30 to 8.14 injuries per 1000 exposure hours were reported within the adolescent athletes which shows that they are at high risk of being injured (e.g. Beachy and Rauch, 2014; Malisoux et al., 2013; Theisen et al., 2013; Vanderlei et al., 2014). Overall, these studies suggest that the most common area of injury among adolescents are the lower limbs. However, during PE lessons upper limbs are frequently injured as well, with hand and finger injuries occurring most commonly (Kelm et al., 2001). These high incidence rates were the driving forces to launch this dissertation in the first place and no additional epidemiologic study in this population was conducted.

3.2. Aetiology of injuries (Step 2)

It has previously been demonstrated in the literature that PE teachers have multiple work-related risk factors (physical work load on the lower limbs and back in PE teachers; Sandmark et al., 1999; kneeling/squatting, heavy lifting, walking/standing cause higher risks of lower limbs injuries; Okunribido & Wynn, 2010; awkward lifting and prolonged periods of standing; Sterud and Tynes, 2013). Furthermore, the considerable sports participation history (Sandmark, 2000) and current sports participation (Pihl et al., 2002) place them at higher risk. In line with previous studies in multi sports populations (Goossens et al., 2014; Kucera et al., 2005), our epidemiologic study (chapter 1) added to the literature on injuries among PE teachers by revealing that a history of previous injuries increased the risk for injuries. Additionally, higher injury incidence in PE teachers was related to a higher physical load during intra-curricular teaching.

No contributions were made for this step of the TRIPP model for adolescents, although in the general introduction some main risk factors out of the literature were provided (1.4. Injury risk factors of adolescents).

3.3. Development of an intervention for the prevention of injuries (Step 3)

For the development of an intervention for injury prevention we could rely on the existing multifactorial primary sports injury prevention program, namely “No Gain With Pain” (NGWP; Goossens et al., 2015a). The target population in NGWP, namely PETE students, ties in closely with our target population of PE teachers due to their active

lives with a multisport character. When optimizing the intervention, it was important to consider both the content of the intervention and the way it was delivered.

The fairly new approach in this dissertation was the optimization of NGWP with PE teachers, based on appreciation scores and focus group conversations (chapter 2). A cyclic process of implementation, evaluation, and optimization was conducted to let the program correspond to the wishes and needs of the PE teachers (similar to Aelterman et al., 2013). The great added value was that both and content and delivery of the intervention could be scored and suggestions could be given by PE teachers on how to optimize the intervention. In line with recommendations from the literature, teachers from different schools were brought together during the intervention (Armour and Makopoulou 2012; Garet et al. 2001) so that they could interact with each other and share ideas (Armour and Makopoulou 2012; O'Sullivan and Deglau 2006). In future intervention optimizations, this cyclic process and research method is highly recommended, as high appreciation scores were reported among participants and upon completion an intervention that meets the wishes and needs of the target population was available. This high appreciation may induce a better adherence to the program and would be tested in a next step.

Secondly, motivators/barriers were already questioned during the optimization study (chapter 2). On the one hand, the two biggest barriers to really implement preventive behavior were the lack of time and not finding the will to get started. On the other hand, teachers indicated to be more motivated to implement the injury prevention strategies through participation in a group event, if they would receive an intervention that can be applied in daily life, or when they would be injured. To solve the lack of time-barrier, examples of small exercises that are easily implementable in daily life (e.g. standing on one leg while brushing your teeth) were suggested to the teachers. This is in line with the view that to be able to put the theory into practice, it is crucial to connect with teachers' everyday practice (Armour and Yelling 2004; Garet et al. 2001). Stimulating the will to get started was obtained by integrating SDT in the delivery approach, which presumably fostered PE teachers' autonomous motivation (Deci and Ryan, 2000).

Table 2 provides a short overview of the beneficiaries, delivery methods and content of NGWP, and the new items in each of the adapted versions of NGWP (1.0 – 2.0 – 3.0). As in the "adapted NGWP 1.0" most changes were made due to the cycles of implementation, evaluation and optimization, an overview of the main changes are given in appendix 3. More details of the adaptation of "adapted NGWP 2.0" can be found in chapter 4 (*Intervention*) and of the new items in "adapted NGWP 3.0" in chapter 5 (*Intervention*).

As is seen in table 2, the different versions of NGWP are aimed for different target populations. Where initially the intervention was made for PETE students (in PETE students and through their sport lecturers), in the current study, the adapted version NGWP 1.0 was meant for PE teachers to implement preventive strategies in their own sporting activities, NGWP 2.0 added the aim to reach injury prevention through PE teachers towards adolescents in PE lessons, and NGWP 3.0 additionally aimed to reach adolescent athletes through PE teachers who are also active as a trainer in a sports club. So, the target population extended over the different versions of NGWP, which concurs of course with the two main aims of the study, as derived from the conceptual model that strives to reach all adolescent sports active youngsters through engaging PE teachers more in their own injury prevention and towards the pupils and youngsters that they teach in PE or train in a sports club.

Table 2. An overview of NGWP, and the main changes in the adapted versions (1.0, 2.0 and 3.0)

NGWP	**Adapted NGWP 1.0**	**Adapted NGWP 2.0**	**Adapted NGWP 3.0**
Beneficiaries		Beneficiaries	
PETE sports lecturers towards the PETE students; PETE students	PE teachers in own sporting activities	PE teachers in own sporting activities and towards adolescents in PE lessons	PE teachers in own sporting activities and towards adolescents in PE lessons and towards adolescent in trainings
Delivery methods:		New in the delivery methods:	
theoretical-practical workshop (3h) in PETE sports lecturers; theoretical-practical workshop (1.5h) in PETE students hand-outs website posters in	After three cycles of implementation, evaluation & optimization: theoretical part (1h45) - practical part I (1h45) – practical part II (2h30) Hand-outs; a 12-week exercise program; 50 didactical posters with suggestions of repetitions and sets of exercises for PE teachers and indication of level difficulty of the exercise; access to a website including rationale of the preventive strategies, didactical posters and illustration videos SDT elements included in the delivery approach of the trainer towards PE teachers (e.g. introducing round, posing many questions, allow choices in exercises, allow success experiences, etc.) All provided preventive strategies could be tested in the practical parts	Theoretical part (1h45), practical part I (1h45), practical part II (2h30) 136 didactical posters adapted to pupils' level, and on the back side of the didactical poster a figure indicating the active muscle(s) during that specific exercise was added Reminders for PE teachers to implement the injury prevention SDT elements were suggested and could be tried out during the practical part to include into PE lessons towards the adolescents (e.g. an attractive memory game with functional strength exercises was provided	Theoretical part (1h45) - brainstorm session in which PE teachers could discuss and be creative about implementing SDT in their PE lessons and trainings (45min) – practical part (3h30) Secured Facebook page to share ideas and good practices SDT elements were suggested and could be tried out during the practical part to include into training towards adolescent athletes (e.g. own suggestions or shared ideas made during the brainstorm session could be tried out in the practical part)
Content:		New in content:	
injury epidemiology in PETE students, rationale for preventive strategies, implementation tips, SDT-based delivery tips, encouragement to use appropriate footwear for each sports discipline, respect potential cues indicating pain or overuse, respect the physicians' advice for treatment and period of inactivity	injury epidemiology in PE teachers	injury epidemiology in the overall adolescent population SDT-based delivery tips on how to include the delivery approach towards the adolescents in PE lessons	injury epidemiology in the most practiced sports in Flanders SDT-based delivery tips on how to include the delivery approach towards the adolescent athletes in trainings

NGWP initially comprised a theoretical-practical workshop (3h) in PETE sports lecturers and a theoretical-practical workshop in PETE students. Additionally, hand-outs, access to a website containing the delivered information and posters to remind PETE students were given. In NGWP 1.0 a theoretical part (1h45) and two practical parts (1h45 and 2h30) were offered to the PE teachers. Hand-outs of the theoretical part were also provided, a 12-week exercise program was suggested to be followed, access to a newly developed website on injury prevention was given and 50 didactical posters were handed. SDT elements were included in the delivery approach of the trainer towards the PE teacher, so no explicit information on SDT was given to the teachers. In NGWP 2.0 the amount of didactical posters was expanded and adapted to pupils' level. Reminders (e.g. posters, small movies, mails) were also added to remind the PE teachers of implementing the preventive strategies into their own sporting activities and into PE lessons. SDT was also explained during the workshop and examples of SDT-based methods could be explored during the practical part. Whereas in NGWP 2.0 suggestions were given to implement SDT, in NGWP 3.0, a brainstorm session (45min) was added to discuss the implementation of SDT in both PE lessons and training sessions and to share ideas. Moreover, a secured Facebook page allowed for sharing of ideas and good practices after receiving the intervention among the participants. Lastly, the SDT –based ways of delivery, discussed during the brainstorm session, could be tested during the practical part. So SDT elements were first of all provided during the delivery approach towards the PE teachers (e.g. trainer allowed interaction, allowed choices in exercises, created success experiences), then taught towards the PE teachers to implement in PE lessons (e.g. pupils feel confident by posing questions they can easily respond, they experience success by providing differentiation in exercises) and finally taught to implement in training towards the adolescent athletes as well (e.g. making the exercises more sport specific (e.g. including a volleyball while performing prone bridge during a volleyball training) and induce success experiences (e.g. different levels in exercises), feel connected with the other athletes by working in pairs).

In terms of injury prevention strategies, NGWP includes 7 intrinsic (warm up, pre-activity dynamic stretching, post-activity static stretching, core stability, dynamic lower extremity stabilization, functional lower extremity strengthening, and technical training

for correct landing and cutting movement execution) and one extrinsic (appropriate footwear) strategy. A multifactorial approach including a balanced use of different strategies was chosen as this has been proven to be effective (Parkkari et al., 2001). The content of the strategies did not change over "adapted NGWP 1.0, .0 and 3.0", but added values of the different versions of the intervention was created by first of all implementing specific elements that are relevant for PE teachers found in chapter 1 (e.g. mostly focus on lower extremity, back and shoulder exercises) and attention for some work-related risk factors (e.g. learning how to correctly assist pupils during an exercise or placing materials back-friendly) in NGWP 1.0. Secondly, injury epidemiology in the overall adolescent population, based on the literature, and SDT-based delivery tips on how to include the delivery approach towards the adolescents in PE lessons were added in NGWP 2.0. Thirdly, injury epidemiology in the most practiced sports in Flanders, based on the literature, and SDT-based delivery tips on how to include the delivery approach towards the adolescent athletes in trainings were added in NGWP 3.0.

High appreciation scores were detected (chapter 2), good adherence to the programs was reported (chapter 2, 3, 4 and 5) and great interest in the delivery approach was shown (chapter 2) in the different versions of NGWP, which predicted the intervention would be effective in reducing injuries.

3.4. Effectiveness of sports injury prevention (Step 4)

The effectiveness of the adapted versions of NGWP was scored on outcomes of PE teachers' appreciation score of the intervention (chapter 1), confidence to apply (chapter 1), preventive knowledge about (chapter 2, 4 and 5), their perceived utility of the provided strategies (chapter 2 and 5), injury incidences in PE teachers (chapter 3), and their preventive behavior in their own sporting activities (chapter 2, 3, 4 and 5), in PE lessons towards the pupils (chapter 4 and 5) and in training sessions towards the adolescent athletes (chapter 5). An overview of these outcomes is given in table 3 and 4 and more detailed information was given in the section *2. Summary of the main results*. Effectiveness is defined here as the assessment of the preventive effect of a measure under everyday circumstances and with little or no control over how the measure is implemented. Effectiveness is opposed to efficacy, which is the assessment of the

preventive effect of a measure under ideal and tightly controlled conditions (Finch, 2010).

Table 3. Summary of the overalll changes in appreciation score of the intervention, and confidence to apply, knowledge about, and perceived utility of the preventive strategies in intervention (compared to control) group, after receiving an adapted (1.0, 2.0, 3.0) version of NGWP.

	Adapted NGWP 1.0		Adapted NGWP 2.0	Adapted NGWP 3.0
	Chapter 2	Chapter 3	Chapter 4	Chapter 5
Appreciation score	↗	not assessed	not assessed	not assessed
Confidence to apply	↗	not assessed	not assessed	not assessed
Knowledge	↗	not assessed	↗	↗
Perceived utility	↗	not assessed	not assessed	↗
Injury incidence	not assessed	↘	not assessed	not assessed

Figure 4. Summary of the changes in preventive behavior in intervention goup, compared to the control group over time, after receiving an adapted (1.0, 2.0, 3.0) version of NGWP.

	Adapted NGWP 1.0	Adapted NGWP 2.0		Adapted NGWP 3.0		
	Chapter 3	Chapter 4		Chapter 5		
	OWN	OWN	in PE	OWN	in PE	in TR
OVERALL	≈	↗	↗	↗	↗	↗
Correct performance					↗	↗
Warm up		↗	↗		↗	↗
Cool down		↗			↗	
Dynamic stretch	↗	↗	↗		↗	
Static stretch	↗	↗	↘			
Core stability	↗	↗		↗	↗	
Balance	↗	↗		↗	↗	
Strength	↗	↗		↗	↗	

OWN=in own sport activities, in PE=in PE lessons, in TR=in trainings activities in a sports club

As Aelterman et al. (2013) found that teachers' intention to apply the proposed strategies in their own practice was positively correlated with the global appreciation of the intervention, it was suggested that increasing teachers' appreciation of an intervention might increase teachers' adherence to the proposed strategies.

Moreover, according to the self-determination theory (SDT, Deci and Ryan, 2000), the willingness to engage in the proposed strategies will be higher when participants understand the personal usefulness of the preventive strategies and feel confident and competent to apply the strategies (Aelterman et al., 2013). Apart from these two

parameters (utility and confidence), improvement in knowledge is also suggested to positively affect adherence (Wang, Lin, and Huang, 2012).

Indeed, a literature review made clear that efficacy of sports injury prevention is related to users' adherence to the provided program (Myklebust et al., 2003; Verhagen et al., 2011; Verhagen et al., 2014). Injury prevention needs a behavioral change (Verhagen et al., 2010) and therefore we not only focused on the content of the interventions, but also relied on an empirically validated theory, that is SDT, in the delivery approach of the intervention (Chan & Hagger, 2012; Deci & Ryan, 2000). By systematically optimizing the intervention, the effects could be gradually enlarged as in shown in table 4.

The most valuable outcome of the intervention is the injury incidence. Whereas in PETE students, NGWP resulted in a trend towards significance lower injury incidence (Goossens et al., 2015a), a significant reduction was found among PE teachers in the studies included in the current dissertation (chapter 3). This more clear effect in PE teachers may be due to the extensive optimization process (chapter 2).

3.5. Description of the context for sports injury prevention (Step 5)

The fifth step of TRIPP-model is necessary to understand how the outcomes of the effective research can be translated into actions that can be actually implemented in the real-world context of on-field sports behaviors and sports delivery. Hereby most important questions are: 1) What are current safety behaviors and do they need to change? 2) What are the motivators/barriers to uptake? (Finch, 2006).

To answer the first question, results of the control groups in chapter 3, 4 and 5 can be taken into account. An average of 36.4 min of preventive behavior per week was reported in 26 PE teachers (CHAPTER 3) and a mean score of 22.5 min (CHAPTER 4) and 33.0 min (CHAPTER 5) per training of 60 min was reported in 7 and 24 PE teachers of the control group. Hereby, mainly emphasis was put on warm up, static stretching and strength training. However, in chapter 3 it was seen that not the amount of time spent on injury prevention was the main key to reduce injury incidence, but the way you spent this time was. Therefore a main swift needs to take place in injury preventive behavior in PE teachers in terms of applying the preventive strategies in a balanced way and not

necessary a time increase was aimed for (chapter 3). So, whereas now focus is given to three preventive strategies, a change towards the implementation of eight strategies should be aimed at.

Secondly, motivators/barriers were already questioned during the optimization study (chapter 2). On the one hand, the two biggest barriers to really implement preventive behavior were the lack of time and not finding the will to get started. On the other hand, teachers indicated to be more motivated to implement the injury prevention strategies through participation in a group event, if they would receive an intervention that can be applied in daily life, or when they would be injured. To solve the lack of time-barrier examples of small exercises that are easily implementable in daily life (e.g. standing on one leg while brushing your teeth) were suggested to the teachers. This is in line with the view that to be able to put the theory into practice, it is crucial to connect with teachers' everyday practice (Armour and Yelling 2004; Garet et al. 2001). Stimulating the will to get started was obtained by integrating SDT in the delivery approach, which presumably fostered PE teachers' autonomous motivation (Deci and Ryan, 2000). Moreover, a better understanding of the knowledge and attitudes of PE teachers in relation to the frequency, causes and prevention of injuries in their sport-context has been advised (Finch, 2006). Therefore, measurements of teachers' knowledge and attitude, in terms of perceived utility towards the preventive strategies, were assessed as well (Vercruysse et al., 2016b; Vercruysse et al., submitted b). Low pre scores of knowledge about, perceived utility of and confidence in the provided strategies show an urgent need of implementing injury prevention within this population. After receiving the intervention, PE teachers increased in the latter three outcomes, which means that the intervention can induce an increased knowledge and attitude towards injury prevention.

3.6. Real-world implementation and effectiveness evaluation (Step 6)

The real-world implementation of the injury prevention intervention in PE teachers would be the next step in TRIPP model. However, before real implementation is possible, some issues should be further developed. First of all, a more efficient behavior and injury registration system is needed as the used online tool in this dissertation

caused a large drop-out (chapter 3) if registrations were needed over a long period of time (e.g. one school year). Secondly, in the current dissertation two instructors, working at Ghent University, were able to deliver the intervention towards PE teachers. If this intervention is wanted to be implemented in real-world, train the trainer sessions should be organized. Intervention deliverers not only need didactical skills, they also need training in the delivery approach based on SDT, and are preferably driven by autonomous motivation for the topic themselves. A next issue is the costs (e.g. didactical posters, transport costs, trainers, materials, working hours for the injury registrations and analysis, etc.) of providing such interventions in real-world. In this dissertation, studies were supported by the Flemish Policy Research Centre on Sports and the Flemish government. A similar funding should be needed in future as well if step 6 is wanted to be realized.

4. Strengths and limitations of the current research project

The first strength of this dissertation is the cyclic optimization of an existing intervention program through a process of implementation, evaluation and optimization. Thanks to this optimization, the intervention met the needs and wishes of the PE teachers which resulted in high appreciations scores of and good adherence to the program. Secondly, the execution of three randomized controlled trials made it possible to robustly investigate the effects caused by the intervention. Moreover, the RCTs were conducted in three different populations and all resulted in positive effects. This gives confidence in the success of the intervention. As a third strength, prospective registrations were assessed in all studies, which increased the reliability of the registrations as no recall bias will appear (Gabbe et al., 2003). In previous studies (e.g. Pihl et al., 2002) mostly retrospective registrations were assessed, which strengthens the need of conducting prospective studies. Fourthly, by relying on SDT in the delivery approach (Chan & Hagger, 2012; Deci & Ryan, 2000) to enhance adherence to the program, behavioral change was fostered (Verhagen et al., 2010). Not only did we rely on SDT in the delivery approach of the intervention, part of the intervention also focused on how PE teachers or sport coaches can act in a more motivating way as to autonomously motivate adolescents to adhere to the preventive strategies. Finally, different research methods, assessing both qualitative and quantitative data and using SPSS Statistics 21 (IBM SPSS

Statistics for Windows, Version 21.0. Armonk, NY: IBM Corp.), MLwiN 2.31 (Rasbash et al., 2014) and NVIVO Version 9.0 (Gibbs 2002) were executed.

A first limitation of this dissertation is the lack of injury registrations in adolescents. As no effects on injury incidence in adolescents due to the intervention were measured, no conclusions of the effects within this population can be given. Secondly, the implementation of injury prevention towards adolescents, reported by PE teachers/trainers, was shown in training, but self-reports by students are lacking. Preventive behavior was questioned through PE teachers and an attempt was made to assess preventive behavior in adolescents as well (chapter 4), but as attention was lost and questions were answered randomly or skipped, the results of the adolescents themselves were not useful. According to the injury and behavior registration system, in the future, shorter questionnaires or different methods should be developed to maintain focus, reduce registration time and hereby minimize dropout in PE teachers. Concerning the registrations of injury type, a validity check and a secondary assessment of a (sports) physician and physiotherapist of each registration may be of added value in future research. Thirdly, the injury prevention program is general, basic and intended for multi-sports populations. Whereas adolescents active in a sports club may rely on the creativity of their trainer to adapt the basic exercises to more sport-specific exercises, adolescents participating in non-organized sports are on their own. So the latter group of adolescents may need extra attention in further research. Subsequently, the injury and behavior registration system in the current dissertation was an online tool with self-reports of the PE teachers, which needed to be filled out weekly. It was difficult for PE teachers to consistently register, causing considerable dropout (28%) in the effect study (chapter 3). Therefore, alternative registrations methods are desirable to minimize dropout, but still need to be able to obtain reliable findings. One possible alternative is the use of a text-message to easily and briefly ask for the occurrence of an injury, in contrast to the more comprehensive method of opening an external link, sent by email such as in this dissertation (Verhagen and Bolling, 2015). Another limitation in this dissertation is the relatively high attrition bias (i.e. selection bias caused by loss of participants), especially in chapter 3. This is mostly caused by the long period of registration (10 months) and extensive questionnaires. A post hoc analysis in G power

for the study in chapter 3 resulted in a power of 0.68, which does not meet the generally accepted power of 0.80 that is needed to indicate that enough subjects participated in the study. This may have led to a greater dispersion of the results in both groups. Similar, the reports of the seven PE teachers in every condition in chapter 4 are diverse, seen in the high standard deviations, and may have influenced the p-value. Despite the small sample sizes, still clear results were found in all chapters, but future research in larger populations may strengthen the results. Lastly, in order to avoid further drop out, relatively short follow-up periods were used in this dissertation, while it is desirable to have a follow-up after two years to see if the intervention still obtains its effects.

5. Practical implications

The epidemiologic data in PE teachers (chapter 1) revealed that PE teachers indeed suffer from a high injury incidence. Future injury prevention within this population is therefore needed with a focus on lower limbs, back and shoulder.

We learned from the high appreciation scores and various positive quotes in the focus group conversations that the cyclic process of implementation, evaluation and optimization is beneficial in the development of an intervention (chapter 2). Recommendations for this cyclic process can be made for future research, trying to develop or optimize an intervention.

The “Adapted NGWP 1.0” has shown its effects on reducing injuries in PE teachers (chapter 3) and might therefore receive attention for implementation in the whole of Flanders. The three versions of NGWP (1.0, 2.0 and 3.0) induced an increased injury preventive knowledge in PE teachers and an increased implementation of the preventive strategies in PE teachers’ own sporting activities (1.0, 2.0, 3.0), in PE lessons towards the students (2.0, 3.0) and in training sessions towards the adolescent athletes (3.0). The latter confirms the assumption that an increased injury preventive implementation in own sports activities may enlarge the implementation in other settings (PE lessons or trainings) as well. Perceived utility of the provided strategies increased in teachers’ own sporting activities (1.0, 3.0) and in PE lessons towards the students (3.0). Therefore, as good assumptions can be made on injury implementation towards the adolescents,

further investigation of the effects of “adapted NGWP 3.0” on injury incidence may be conducted in this population.

Not only in-service, but also pre-service PE teachers would benefit from the intervention. NGWP was a program initially developed for PETE students and the encouragement of injury prevention implementation in the education program to become a PE teacher can only be emphasized. Specific courses within the education program can be given concerning the injury prevention topic and sports lecturers may include the preventive strategies into their sports lessons.

Moreover, as the intervention is made for a multi-sports population, other populations such as the military population or sport trainers with a physically active job, may also benefit from the program.

Of course, the implementation of the program into the adolescent athletes should not be missed. As adolescents have many different sports offered during PE lessons and the interest amongst adolescents is very diverse, this multifactorial approach can serve as a perfect base for injury prevention. However, some sport-specific elements may possibly strengthen the effect of the program. Further research within this population is needed to understand its effect on injury incidence in adolescent athletes. In this dissertation, besides reaching all youngsters in PE lessons, extra focus was put on reaching adolescents in organized sport settings (training sessions with a trainer). However in future, also extra focus on young athletes in non-organized sport settings (e.g. running, fitness) is wanted as sport participation is most commonly done in non-organized sport activities (Scheerder et al., 2015).

6. Conclusion and future research objectives

An optimized version of NGWP was created and has shown to be effective in reducing injuries in PE teachers, which demonstrates the success of systematically optimizing an intervention in cooperation with the specific target population. Thus, the further implementation of the preventive strategies in PE teachers’ own extra-curricular sporting activities in order to decrease injury incidence, is important. Thereby assessing severity of the injury and sick leave would provide additional information.

It is clear that all in-service PE teachers in Flanders would benefit from the intervention and a large implementation of the intervention is to be pursued.

We started this dissertation however by explaining the need of injury prevention in sports active youngsters and the potential role of PE teachers. It was hypothesized that physical education teachers would implement more injury preventive strategies in their PE lessons, and thus transfer to youngsters, if they were implementing the strategies more in their own lives as well (↗ ; figure 1; De Clercq et al., 2011). As is seen in table 4, paired with the overall increased implementation of preventive strategies in own sports activities, indeed an increased implementation in PE lessons was reported. The same assumption was made for physical education teachers, which were also active as trainers in a sports club, towards the young athletes in clubs (↗ ; figure 1; De Clercq et al., 2011). The study of chapter 5, aiming at implementing injury prevention in three different sports contexts in or through PE teachers, confirmed this assumption and showed that together with a higher implementation of injury preventive strategies in teachers'/trainers' own sports activities, again an increase of the implementation in PE lessons, as well as in sports training sessions was found. We should be aware that, because this "adapted NGWP 3.0" mainly focused on the transfer towards the adolescents effects were more clear for the PE lessons, and a reduction of the effects for teachers' own sport participation was found. Therefore, future versions of the NGWP program should aim at establishing effects in all three contexts (PE teacher, PE lessons, sports training sessions) through one and the same intervention.

Thereby the clear carry over effect from PE to sports club is a strong support for investigating the remaining pathway in the model of De Clercq et al. (2011) that has not been examined yet, namely the implementation of injury prevention from students in PE towards their own (non-) organized sport activities (↗). A randomized controlled trial, training PE teachers to implement injury prevention in PE lessons, and with combined registrations of preventive behaviour in adolescents during PE lessons and in their own sporting activities should give insight in the latter pathway. Additionally, refinement of the assessment of preventive behaviour could be done with video-based observations on the quality of the reported injury preventive behaviors. An observational tool similar

to Fortington et al. (2014) could be developed and validated to assess the quality of the preventive exercises.

Moreover, as teachers' motivation to implement injury prevention was not assessed yet in this dissertation, but the intervention was given to the teachers taking into account the principles of the self-determination theory, a questionnaire assessing teachers' motivation would be desirable to gain insight in their motivational changes. Items of the adapted Dutch version of the Behavioral Regulations in Exercise Questionnaire used in Aelterman et al. (2012) can form a good basis to start from. In that way all types of regulation (see figure 3 in the general introduction) can be assessed. As in future research in whole Flanders it will be intended to encourage both teachers with optimal and less optimal forms of motivation, insight in their quality of motivation will be of added value to find out what are the effects of the injury prevention intervention on teachers' motivation. Not only teachers' own motivation but also the perception of the teachers about the delivery approach of the training (e.g. Did you have a feeling of success experience during the training?) and the trainer (e.g. Did the trainer create a sense of connectedness between the participants?) would be useful information. In that way, a fidelity check of the intended implementation of SDT in the delivery approach can be done. Overall, an intervention reaching as much as possible PE teachers in Flanders and stimulating their autonomous motivation in the best way to implement injury prevention in the long-term is pursued.

In conclusion, the optimized versions of NGWP proved to be effective in PE teachers by increasing their injury preventive behavior, lowering their injury incidence and increasing the implementation of injury preventive strategies in their PE lessons and in their sports training sessions. The former highlights a promising pathway to reach all potentially sports active youngsters. Measuring the effect on preventive behavior in adolescents, and ultimately on injury incidences requires further investigation.

Based on our research, we advocate that injury preventive strategies in the form of the optimized NGWP program should be delivered to all in-service PE teachers, included in the education of pre-service teachers and implementation in other multi-sport populations may be considered.

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APPENDICES

Appendix 1. Mean amount of minutes per extra-curricular sporting activity of 60 min PETs applied per preventive strategy, reported by the PETs themselves, on three moments in intervention (INT) and control (CON) group. Pre in January, Post in February and Follow-up in March

	INT			CON			Interaction effect		
	PRE	POST	FU	PRE	POST	FU	PRE- POST	POST-FU	PRE-FU
CP	15,8	18,7	12,3	5,9	4,2	4,0			
WU	3,4	10,6	3,3	5,1	4,7	5,0	**	*	
CD	0,9	3,3	2,0	2,8	1,6	2,8	*		
DS	0,2	2,8	1,7	2,8	0.0	0,4	**		*
SS	3,5	3,9	2,3	3,3	0,6	2,0	*	*	
CORE	1,6	3,2	4,9	3,2	1,2	1,7	*		*
BAL	0,6	1,9	3,0	2,0	1,2	0,7	*		*
STR	1,5	4,2	7,7	3,9	3,0	1,9	*		

CP = correct performance, WU = warming up, CD = cooling down, DS = dynamic stretch, SS = static stretch, CORE = core stability, BAL = balance, STR = strength, $p^{*}<0.1$, $p^{**}<.05$, $^{***}p<.01$

Appendix 2. Mean amount of minutes per PE lesson PETs implemented each preventive strategy, reported by the PETs themselves, on three moments (pre, post, follow-up) in intervention (INT) and control (CON) group.

	INT			CON			Interaction effect		
	PRE	POST	FU	PRE	POST	FU	PRE-POST	POST-FU	PRE-FU
CP	12.7	19.7	34.9	14.6	15.0	21.3			
WU	6.9	8.3	11.7	8.3	4.9	6.6			*
CD	1.4	2.6	2.9	7.4	2.0	0.3			
DS	0.6	2.6	6.0	0.6	1.7	0.0		**	***
SS	4.6	1.7	3.7	1.4	0.0	0.0			**
CORE	2.9	4.0	3.1	5.4	0.9	0.0			
BAL	2.3	2.6	2.6	2.0	1.4	0.0			
STR	2.3	4.0	3.4	0.9	3.4	0.0			

CP = correct performance, WU = warming up, CD = cooling down, DS = dynamic stretch, SS = static stretch, CORE = core stability, BAL = balance, STR = strength, $p^{*}<0.1$, $p^{**}<.05$, $^{***}p<.01$

Appendix 3. Changes made based on the suggestions in the focus group conversations and appreciation questionnaires in chapter 2 towards an optimized "adapted NGWP 1.0"

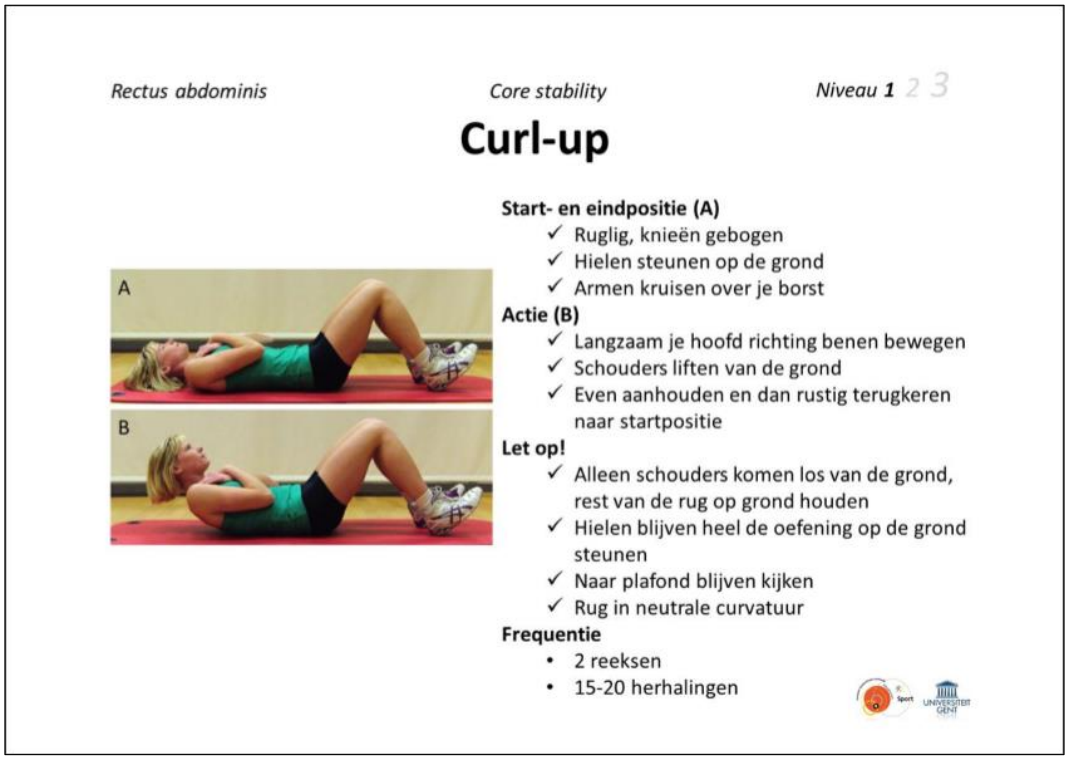
	Version 1 – Version 2	Version 2 – Version 3
Theoretical part	▪ Starting the training with a clear overview of the topics that will be addressed ▪ Using more intelligible words *e.g. Dutch instead of Latin indications of the muscles* ▪ Being sure that everybody understands the basic elements *e.g. Asking if someone can explain the difference between static and dynamic stretching with an example*	▪ Making the theory more enjoyable and attractive and excite the teacher's interest e.g. Adding quiz questions and giving little practical try outs ▪ Becoming more used as a trainer to ask questions in a proper and natural way and don't give all the information right away
Practical part	▪ Giving the practical part in a room with mirrors on the wall in order to control body posture ▪ Using Dutch terms instead of Latin or English ▪ Showing some important exercises per body part in the beginning while stressing on important aspects ▪ Using more intelligible words *e.g. Dutch instead of English names for the kind of training*	▪ Changing the didactical posters by use of teachers' suggestions and using information written by Mayer & Moreno (2003), e.g. Levels, active muscle groups, frequencies, organization of images and text ▪ Making it clear that teachers may teach each other ▪ Presenting the exercises to a group of professional physiotherapists and ask for suggestions ▪ The practical part may take a little longer
Other	▪ Adding the option 'inapplicable' in the questionnaires	▪ Making the suggested exercise schedule more light *e.g. less repetitions and/or series per exercise*
Further suggestions	▪ All this important information and exercises should be addressed more as well in the education to become a physical education teacher or to become a trainer/coach ▪ Make a list with the most important issues you certainly have to include if you want to make your own exercise schedule	▪ Add some videos and little, shorter practical exercises as well in the theoretical part, because they quoted that physical education teachers do not like to sit quietly ▪ Provide all kinds of small exercises that can be used in daily life and require little effort *e.g. Brushing their teeth on one leg*

Appendix 4. An illustration of the home page (above) of the injury preventive website and part with didactical posters concerning core stability (below)

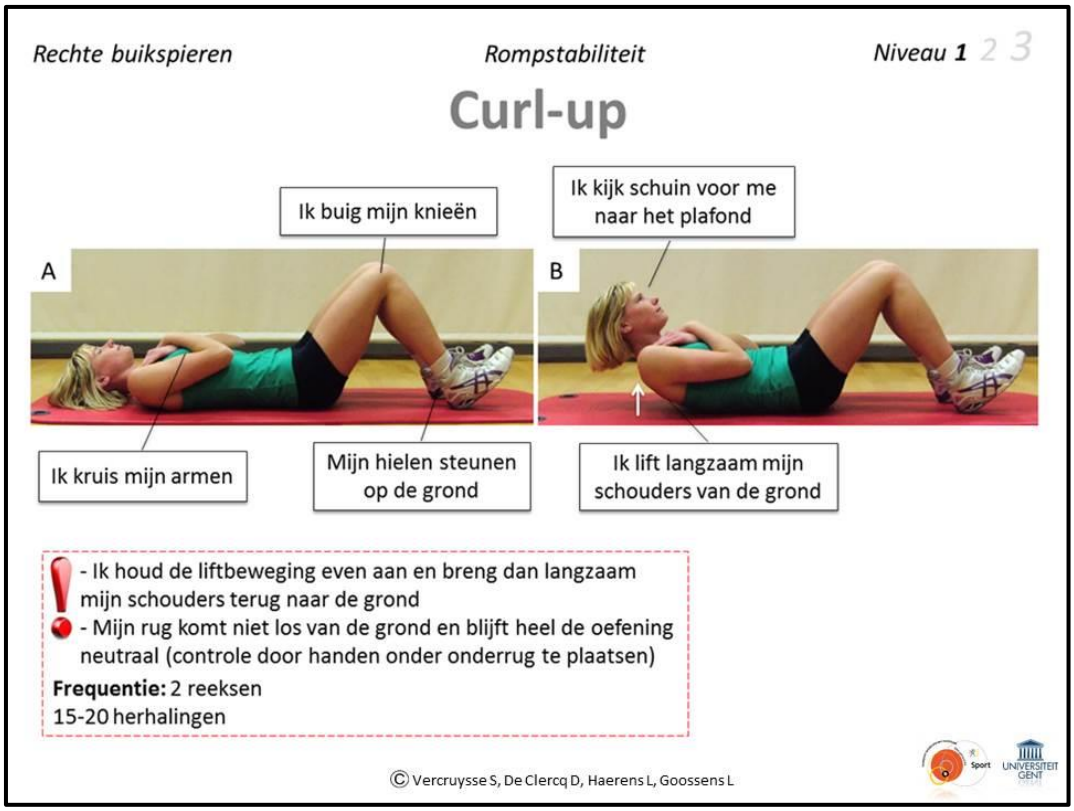
Appendix 5. An example of a poster provided as reminder after receiving the injury preventive trainings.

Appendix 6. Example of the evolution of a didactical poster over the different chapters

The initial layout of the didactical posters used in Chapter 2

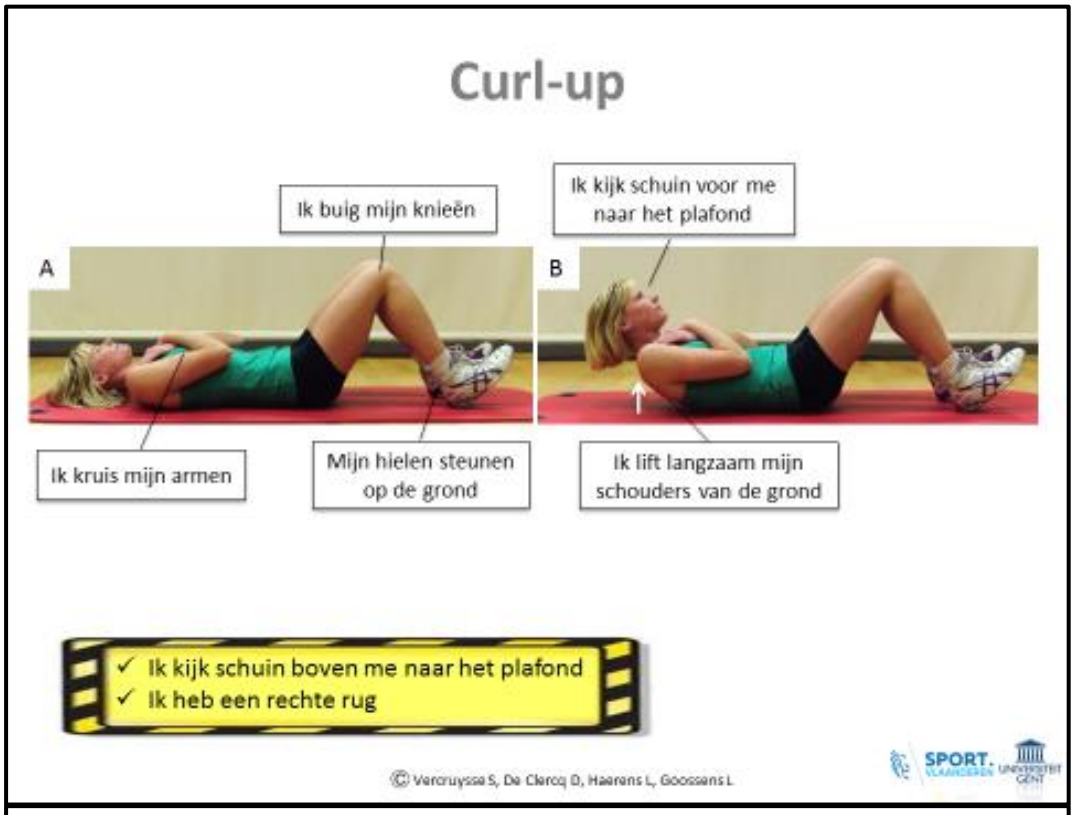


The first adapted version of the didactical posters, used in chapter 2 and 3, after integration of the suggestions given by the phyiscal education teachers



The second adapted version of the didactical posters, used in chapter 4 and 5, with more attention to the simplicity of the posters towards the adolescents

Front



Back

Appendix 7. Weekly registration questionnaire

1. Administratieve gegevens

Om uw antwoorden op deze vragenlijst te kunnen koppelen aan de eerder ingevulde vragenlijst wordt u gevraagd om nogmaals naam en voornaam in te geven.

* 1. Wat is uw naam?

Voornaam:

Naam:

* 2. Duid aan welke week u zal beoordelen:

- ◯ 1-7 februari
- ◯ 8-14 februari
- ◯ 15-21 februari
- ◯ 22-28 februari
- ◯ 29-6 februari/maart
- ◯ 7-13 maart
- ◯ 14-20 maart
- ◯ 21-27 maart
- ◯ 28-3 maart/april
- ◯ 4-10 april
- ◯ 11-17 april
- ◯ 18-24 april

2. Lesgeven LO

* 1. Hoeveel uur Lichamelijke Opvoeding gaf u gedurende de afgelopen week?

◯ 0 ◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯ 6 ◯ 7 ◯ 8 ◯ 9 ◯ 10 ◯ 11 ◯ 12 ◯ 13 ◯ 14 ◯ 15 ◯ 16

◯ 17 ◯ 18 ◯ 19 ◯ 20 ◯ 21 ◯ 22 ◯ 23 ◯ 24

3. Lesgeven LO

* 1. Kies één klas leerlingen (bij voorkeur 2e graad) uit waar u dit schooljaar les LO aan geeft en beoordeel wekelijks volgende vragen voor DIEZELFDE klas.

Van welke onderwijsvorm (ASO, BSO, TSO, KSO) is deze klas?

	JA
ASO	○
BSO	○
TSO	○
KSO	○

* 2. Van welk leerjaar is deze klas?

	JA
1e leerjaar	○
2e leerjaar	○
3e leerjaar	○
4e leerjaar	○
5e leerjaar	○
6e leerjaar	○

Overige (geef nadere toelichting)

* 3. Wat was uw EERSTE lesonderwerp waarrond u werkte in de afgelopen LO les voor uw gekozen klas ?

4. Was er ook een TWEEDE lesonderwerp waar u rond werkte ? Indien ja, welk ?

* 5. Met betrekking tot uw EERSTE lesonderwerp: Geef voor elke preventiestrategie aan hoeveel minuten u besteedde aan het uitvoeren van deze strategie.

Indien u 2 lesuren eenzelfde onderwerp gaf, geef dan het gemiddeld aantal minuten overheen de 2 lesuren dat u aan elke preventiestrategie besteedde.

	0	2	4	6	8	10	12	14	16	18	20	25	30	35	40	45	50
Correcte uitvoering i.f.v. sportletselpreventie (neutrale rugcurvatuur, landingtechniek,...)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Cardiovasculaire opwarming (eventuele stretching hieronder aanduiden)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Cooling down (eventuele stretching hieronder aanduiden)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Dynamisch stretchen	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Statisch stretchen	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Rompstabiliteit	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Balans	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Kracht bovenste ledematen i.f.v. sportletselpreventie	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Kracht onderste ledematen i.f.v. sportletselpreventie	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

6. Met betrekking tot uw TWEEDE lesonderwerp: Geef voor elke preventiestrategie aan hoeveel minuten u besteedde aan het uitvoeren van deze strategie.

	0	2	4	6	8	10	12	14	16	18	20	25	30	35	40	45	50
Correcte uitvoering i.f.v. sportletselpreventie (neutrale rugcurvatuur, landingtechniek,...)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Cardiovasculaire opwarming (eventuele stretching hieronder aanduiden)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Cooling down (eventuele stretching hieronder aanduiden)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Dynamisch stretchen	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Statisch stretchen	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Rompstabiliteit	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Balans	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Kracht bovenste ledematen i.f.v. sportletselpreventie	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Kracht onderste ledematen i.f.v. sportletselpreventie	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

4. Zelf sporten

* 1. Beoefende u zelf sport gedurende de afgelopen week?

- ◯ ja
- ◯ neen

5. Zelf sporten

1. Welke sporten beoefende u zelf gedurende de afgelopen week?

SPORT 1	
Aantal uur recreatief	
Aantal uur training	
Aantal uur competitie	
SPORT 2	
Aantal uur recreatief	
Aantal uur training	
Aantal uur competitie	
SPORT 3	
Aantal uur recreatief	
Aantal uur training	
Aantal uur competitie	

6. Letselpreventie VOOR UZELF

* 1. Hoeveel tijd besteedde u voor UZELF (dit kan op gelijk welk moment zijn; training, lesgeven, thuis,..) in de afgelopen week aan elke preventiestrategie ? Uitgedrukt in aantal minuten en een SOMscore van afgelopen week (vb. 2 keer 15 min opwarmen = 30)

	0	5	10	15	20	25	30	40	45	50	55	60	65	70	75	80	>80
Correcte uitvoering i.f.v. sportletselpreventie (neutrale rugcurvatuur, landingtechniek,..)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Cardiovasculaire opwarming (eventuele stretching hieronder aanduiden)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Cooling down (eventuele stretching hieronder aanduiden)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Dynamisch stretchen	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Statisch stretchen	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Rompstabiliteit	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Balans	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Kracht bovenste ledematen i.f.v. sportletselpreventie	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Kracht onderste ledematen i.f.v. sportletselpreventie	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

7. Training geven

* 1. Geeft u training in een sportclub ?

- ◯ Ja
- ◯ Neen

8. Training geven

* 1. Hoeveel uur training in een sportclub gaf u gedurende de afgelopen week?

◯ 0 ◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯ 6 ◯ 7 ◯ 8 ◯ 9 ◯ 10 ◯ 11 ◯ 12 ◯ 13 ◯ 14 ◯ 15 ◯ 16

◯ 17 ◯ 18 ◯ 19 ◯ 20 ◯ 21 ◯ 22 ◯ 23 ◯ 24

Welke sport?

2. De leeftijd van de groep(en) waar ik afgelopen week training aan gaf is:

3. Deze training gaf ik aan mensen die:

- ☐ competitie spelen
- ☐ recreatief sporten
- ☐ topsporters zijn

* 4. Welke preventiestrategieën kwamen aan bod tijdens de trainingen die u gaf als u dit herrekent tot een gemiddelde training van 1 uur ? Antwoord is weergegeven in aantal minuten. (vb. ik gaf 2 uur training, waarvan 10 min opwarming. Dit wordt hier dus 5 min opwarming!).

	0	2	4	6	8	10	12	14	16	18	20	25	30	35	40	45	50	>50
Correcte uitvoering i.f.v. sportletselpreventie (neutrale rugcurvatuur, landingstechniek,..)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Cardiovasculaire opwarming (eventuele stretching hieronder aanduiden)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Cooling down (eventuele stretching hieronder aanduiden)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Dynamisch stretchen	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Statisch stretchen	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Rompstabiliteit	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Balans	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Kracht bovenste ledematen i.f.v. sportletselpreventie	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Kracht onderste ledematen i.f.v. sportletselpreventie	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

9. Einde

De vragenlijst is beëindigd. Bedankt voor uw registratie!

LIST OF ABBREVIATIONS

SDT	Self-Determination Theory
PE	Physical Education
PET	Physical Education Teacher
SPSS	Statistical Package for the Social Sciences
MLwiN	MultiLevel (ML), windows (wi) and number of levels that can be specified (N)
INT	Intervention group
CON	Control group
RCT	Randomised controlled trial
WHO	World Health Organization
EU IDB	European Injury Data Base
AEs	Athlete-exposures
TOE	time of exposure
NGWP	No Gain With Pain

LIST OF PUBLICATIONS AND PRESENTATIONS

A1 - Articles

Vercruysse, S., De Clercq, D., Goossens, L., Aelterman, N., and L., Haerens. (accepted on 20 Jan 2016). "Development and optimization of an injury prevention intervention for physical education teachers." Physical Education and Sport Pedagogy http://dx.doi.org/10.1080/17408989.2016.1165192.

Vercruysse, S., Haerens, L., Verhagen, E., Goossens, L., and D., De Clercq. 2016. "Effects of a multifactorial injury prevention intervention in physical education teachers: A randomized controlled trial." European Journal of Sport Science 16 (7): 868-876.

Goossens, L.*, **Vercruysse, S.***, Cardon, G., Witvrouw, E., and D., De Clercq. 2015. "Musculoskeletal injuries in physical education versus non-physical education teachers: a prospective study." Journal of Sports Sciences 34 (12): 1107-1115.
*these authors contributed equally to this work

A3 - Articles

Vercruysse, S., De Clercq, D., Goossens, L., and L. Haerens. Decembernummer 2014. "Ontwikkeling en optimalisatie van een motiverend programma voor blessurepreventie bij leerkrachten lichamelijk opvoeding." Tijdschrift voor Lichamelijke Opvoeding 4: 9-11.

Vercruysse, S., Waerlop, S., Haerens, L., Goossens, L., and D., De Clercq. 2015. "Effect of a multifactorial injury prevention intervention on the injury prevalence density in Physical Education teachers: a randomized-controlled trial." Sport & Geneeskunde 2: 41-42.

B2 - Chapter in book

Vercruysse, S. 2016. "Hoofdstuk 9: Primaire preventie van sport- en werkgerelateerde musculoskeletale letsels bij leerkrachten lichamelijke opvoeding: haalbaarheid, effectiviteit en transfereerbaarheid naar de adolescenten." ACCO. Sport in Vlaanderen onderzocht. Resultaten en aanbevelingen voor beleid en praktijk.

C2 - Conference proceedings

Vercruysse, S. 2014. "Development and optimization of an intervention for injury prevention in Physical Education teachers applying SDT." (Abstract from the IOC World Conference on Prevention of Injury & Ilness in Sport (Monaco, France) - Poster presentation) British Journal of Sports Medicine 48: 668.

Vercruysse, S., De Clercq, D, Goossens, L., and L., Haerens. 2014. "Appreciation oriented optimization of an intrinsic intervention for injury prevention in physical education teachers." (Abstract of the 19th annual congress of the European College of Sport Science (Amsterdam, the Netherlands) – Mini oral presentation) Book of abstracts 98.

Vercruysse, S., Haerens, L, Verhagen, E., Goossens, L., and D. De Clercq. 2015. "The effects of a multifactorial injury prevention intervention on physical education teachers' preventive behavior and their sports and work related injuries." (Abstract of the 20th annual congress of the European College of Sport Science (Malmö, Sweden) – Oral presentation) Book of abstracts 83.

C2 - Master thesis

Vercruysse, S., Goossens, L., and D., De Clercq. 2011-2012. "Incidentie van klachten aan het bewegingsapparaat bij leerkrachten Lichamelijke Opvoeding: literatuurstudie en epidemiologisch onderzoek." Masterproef voorgelegd tot het behalen van de graad van Master in de Lichamelijke Opvoeding en de Bewegingswetenschappen. Universiteit Gent.

Creëlle, E., Neirynck, H., **Vercruysse, S.**, and L., Haerens. 2014-2016. "Letselpreventieve gedrags- en kennisveranderingen bij adolescente jongeren en leerkrachten LO in het secundair onderwijs: een leerkracht gestuurde interventie." Masterproef voorgelegd tot het behalen van de graad van Master in de Lichamelijke Opvoeding en de Bewegingswetenschappen. Universiteit Gent.

C2 - Report

Vercruysse, S., Haerens, L., Goossens, L, and D., De Clercq. 2016. "Primaire preventie van sport- of werkgerelateerde musculoskeletale letsels bij leerkrachten lichamelijke opvoeding: haalbaarheid, effectiviteit en transfereerbaarheid naar de adolescenten." Eindrapport Steunpunt Beleidsrelevant Onderzoek Sport 1-30.

Award

Third place for "Gaston – Beunen VK prijs for young investigators 2014" (V.K. Symposium (University of Antwerp), December 12, 2014 - Oral presentation):

Vercruysse, S., Waerlop, S., Haerens, L, Goossens, L, and D., De Clercq. 2015. "Effect of a multifactorial injury prevention intervention on the injury prevalence density in PE teachers: a randomized-controlled trial." Sport & Geneeskunde 2: 41-42.

CURRICULUM VITAE

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Rijksregisternummer:	90.10.04-362.23

Opleidingen

2002-2008	Secundair onderwijs: Wetenschappen-wiskunde 8uur Sint-Jozefscollege Torhout	**Diploma** behaald
2008-2011	Bacheloropleiding lichamelijke opvoeding en bewegings-wetenschappen, Universiteit Gent	**Diploma** behaald met onderscheiding
2010-2011	Trainer B opleiding volleybal Vlaamse Trainersschool - Universiteit Gent	**Diploma** behaald
2011-2012	Opleiding hoger redder Vlaamse Trainersschool - Universiteit Gent	**Diploma** behaald
2011-2012	Masteropleiding lichamelijke opvoeding en bewegings-wetenschappen, Universiteit Gent	**Diploma** behaald met grote ondersch.
2011-2012	Trainer A opleiding volleybal Vlaamse Trainersschool - Universiteit Gent	**Diploma** behaald
2012-2013	Lerarenopleiding in volwassenonderwijs CVO kisp Gent	**Diploma** behaald

Werkervaring

2006 én 2007	*Zomer*	Vakantiejob aan kassa, GB Torhout
2008 én 2009	*Zomer*	Vakantiejob, Dexia woonkredieten Roeselare → Contact: Katherine Vanden Bulcke: 0477/457.771
2010-2011	*Seizoen*	Volleybaltrainer/coach, Kadetten VKt Torhout → Contact: Geert Neels: 0479/984.214 of Pascale Marichal: 0492/734.041
2010-2011	*Academiejaar*	Woensdagtrainingen volleybal 18.30-21.30uur, 'Sociale Voorzieningen Katholiek Hoger Onderwijs Oost-Vlaanderen' →Contact: Lore Michiels: 0474/492.331 of lore.michiels@arteveldehs.be
2011 en 2012	*Paasvakantie*	Paasstage jeugdvolleybal, Hermes Oostende, preminiemen (2011) en kadetten (2012) →Contact: Dries Wittebolle: 0475/41 87 51 of dries.wittebolle@pandora.be
2011-2012	*Seizoen*	Volleybaltrainer/coach, Dames 2e provinciale VKt Torhout →Contact: Marc Vanneste: 0498/446.125 of Geert Neels: 0479/984.214
2011-2012, 2012-2013, 2013-2014, 2014-2015, 2015-2016	*Academiejaar*	Woensdagtrainingen volleybal 19-21uur, hogeschool Gent (Sint-Denijslaan 251) →Contact: Lieve Lemaitre: 092/447.921 of Tom Verriest: 0478/659138

2012 en 2013	*Zomer*	Sporta-kamp Topvolleybalstage Knack Roeselare →Contact: Bart Hungenaert: 0475/331.996 (2012) en Ann Lobbestael: 051/200.536 of Philip Ostyn: 0475/305518 (2013)
2012	*September*	Pretesten afnemen voor project 'Multimove voor kinderen' → Contact: Prof. dr. Matthieu Lenoir: matthieu.lenoir@ugent.be
2012	*Oktober*	Vervanging op de sportdienst van hogeschool Gent → Contact: Tom.verriest@hogent.be of Lieve Lemaitre: 092/447.921
2012-2013	*Seizoen*	Volleybaltrainer/coach, Scholieren (en kadetten) VKt Torhout → Contact: Geert Neels: 0479/984.214 of Pascale Marichal: 0492/734.041
2012-2015		Doctoraatsstudent Universiteit Gent: *Letselpreventie bij en via leerkrachten Lichamelijke Opvoeding (LO): haalbaarheid, effectiviteit en transfereerbaarheid naar de adolescente sport-actieve populatie*
	12/12/2014	"Gaston Beunen" VK Prijs voor jonge onderzoekers, Derde plaats – mondelinge presentatie → Contact: Prof. dr. Dirk De Clercq: 092/646.322 of Prof. dr. Leen Haerens: 092/648.637
2013, 2014, 2015 & 2016	*2e semester*	Lesgever volleybal, Universiteit Gent, vak Bewegen en sport: nu en Later. → Contact: Prof. dr. Dirk De Clercq: 0032(0)92/646.322 of Inge Everaert: 0472/421518
2013-2014	*Seizoen*	Volleybaltrainer/coach, Scholieren VKt Torhout → Contact: Geert Neels: 0479/984.214 of Pascale Marichal: 0492/734.041
2016		1 jaar verlenging doctoraatsstudent Universiteit Gent: Letselpreventie bij en via leerkrachten LO: transfereerbaarheid naar de adolescente sport-actieve populatie (in lessen LO en op training) → Contact: Prof. dr. Dirk De Clercq: 092/646.322 of Prof. dr. Leen Haerens: 092/648.637
2015-2016	*Academiejaar*	Maandagtrainingen aan UGent studenten en UGent personeel van 18-19.30 in GUSB, Gent. → Contact: Geert Delporte: 092/646314
2015-2016, 2016-2017	8 zondagen	Initiatielessen volleybal bij Techfoot Academy (Integratie van andere sportdisciplines bij jonge voetballers) → Contact: Christophe Vandamme: 0486/873.243

Talen

Nederlands:	Moedertaal
Engels:	Goede beheersing in spreken, begrijpen, schrijven en lezen
Frans:	Beheersing in spreken, begrijpen, schrijven en lezen

Automatiseringskennis

Microsoft Office Word	Zeer goed
Microsoft Office PowerPoint	Zeer goed
Microsoft Office Excel	Goed
SPSS Statistics 21	Goed
MLwiN 2.34	Basis


Mama